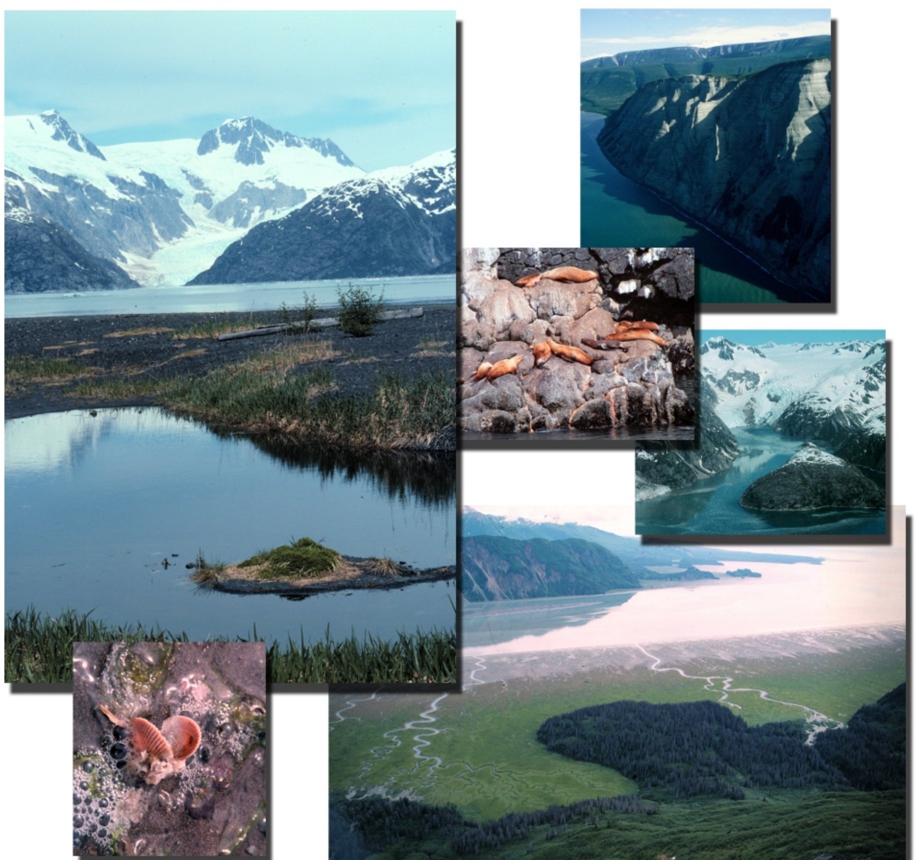
National Park Service - Southwest Alaska Network
Inventory & Monitoring Program

Coastal Scoping & Planning Workshop for Long-term Monitoring Southwest Alaska Network

August 26-28, 2002
Seward, Alaska



Photos by: Page Spencer

Southwest Alaska Network Inventory & Monitoring Program
2525 Gambell Street
Anchorage, Alaska 99501

Coastal Scoping and Planning Workshop
Long-term Vital Signs Monitoring Program
Southwest Alaska Network (SWAN)
26-28 August 2002

Purpose

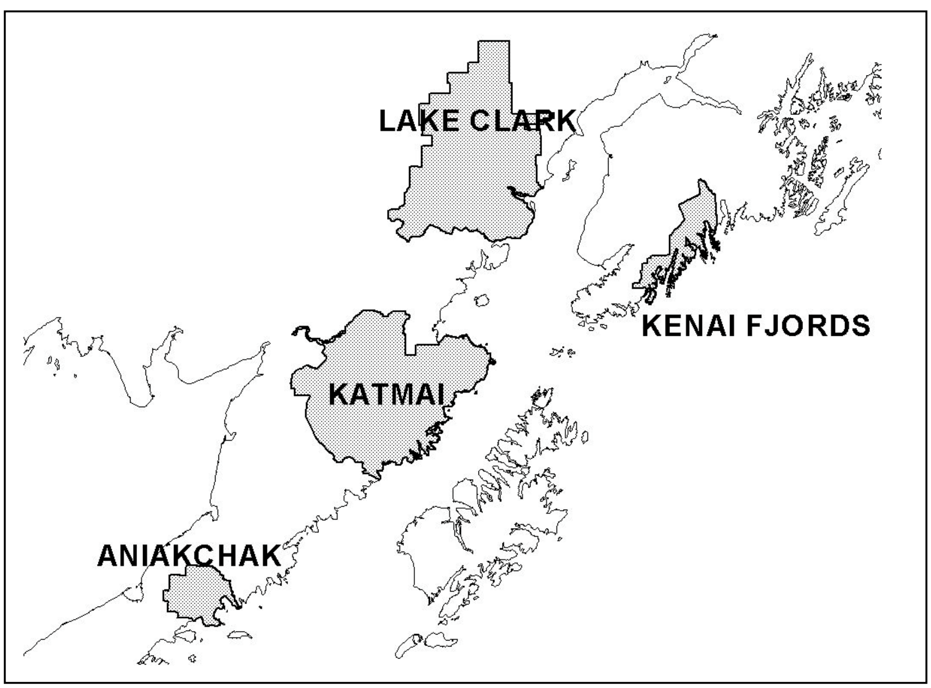
Provide a forum for NPS resource managers and scientists to discuss ideas and options for building a statistically sound, ecologically-based, management-relevant, and affordable coastal monitoring program at SWAN Park units.

Objectives

1. Review and Refine Conceptual Models

2. Identify Specific Monitoring Objectives or Questions

3. Identify Ecosystem Attributes to Monitor.



AGENDA

SWAN Coastal Monitoring Workshop
26-28 August 2002

26 August

	Travel to Seward
6:00 PM	*Dinner* Seward at Ray's Waterfront Restaurant, across the street from the Breeze Inn
7:30-9:00 PM	*Evening Session at Kenai Fjords National Park Visitor Center*
	Welcome- Anne Castellina, Southwest Network Board of Directors, Superintendent, Kenai Fjords National Park (5-10 min)
	Vital Signs Monitoring Program in Alaska National Park Units – Sara Wesser, Regional Inventory & Monitoring Coordinator (10 min)
	M/V Serac Logistics and the trip to Coleman Bay - Ian Martin, Chief of Natural Resources Management (acting), Kenai Fjords National Park (10 min)
	Workshop Procedures and Guidelines - Alan Bennett, Coordinator, Southwest Network, Inventory and Monitoring Program (15 min)
	Initial comments from invited guests on contents of the Scoping Workshop Notebook and other suggestions for the 2-day workshop (15 min each)
	Vernon Byrd, U.S. Fish & Wildlife Service Carl Schoch, Alaska Dept. of Fish & Game Pete Peterson, University of North Carolina
9:00 PM	*Adjourn* overnight at Breeze Inn, Seward

27 August

	Breakfast The Breeze Inn serves breakfast in their restaurant starting at 6:00 AM. The Bakery across from the Kenai Fjords Visitor Center also opens at 6:00 AM
7:45-8:00 AM	Board M/V Serac for 2 hour cruise to Coleman Bay
10:30-11:30 AM	*Session 1* Review and Refine Conceptual Models Page Spencer, Facilitator/Ecologist
11:00-12:30 AM	*Session 2* Identify monitoring objectives and/or questions in line with the 3 network programmatic goals for nearshore coastal monitoring Page Spencer, Facilitator/Ecologist
12:30-1:30 PM	*Lunch*
1:30-3:00 PM	*Session 2 (continued)*
3:00-3:15 PM	*Break*
3:15-5:00 PM	*Session 3* Identify nearshore ecosystem attributes to monitor Page Spencer, Facilitator/Ecologist
6:00 PM	*Dinner*
7:30 PM	Skiff shuttle from Serac to Coleman Bay cabin

28 August

7:30 AM	Skiff shuttle from Coleman Bay cabin to Serac
8:00-9:00 AM	Breakfast
9:15-10:30 AM	*Session 3 (continued)* Identify nearshore ecosystem attributes to monitor
10:30-11:45 AM	*Wrap-up* Discussions and closing comments and suggestions from invited guests (10 minutes each)
12:00 Noon	Lunch and depart Coleman Bay for Seward
3:00 PM	Arrival in Seward

NOTEBOOK CONTENTS

The sections of this notebook represent a skeletal format of what will eventually become the Southwest Networks *Conceptual Foundation for Monitoring*. The framework, objectives, models, and concepts and will be refined during successive workshops and peer review. Ultimately, this information will form the basis for drafting a long-term monitoring plan.

BACKGROUND- Describes the National Park Service's (NPS) multi-phase effort to launch a long-term "vital signs" monitoring program in 270 national park units. Provides an overview of the Southwest Alaska Network's organization, planning approach, and the role of this workshop. Other background information includes a brief overview of network park coastal ecoregions; and a summary of natural resource management issues and on-going monitoring for each park unit.

GOALS- Page one of the this section outlines the relationship between National Park Service Mandates, Network Park and Preserve Mandates, and the NPS Service-wide goals for monitoring. Page two outlines the overall Southwest Alaska network goal and the goals for monitoring coastal-nearshore ecosystems. Identification of specific objectives for nearshore monitoring is a task of workshop participants during session 2. Page three defines the framework requirements for the monitoring program as defined by the SWAN Technical Committee.

MODELS- (Session 1) This section contains a series of draft conceptual models of SWAN coastal ecosystems. These models are based on information contained in network park Resource Management Plans, Technical Committee discussions, and review of published and unpublished reports on coastal nearshore ecosystems in the northern Gulf of Alaska. Refinement of these models or creation of alternative models is a task for workshop participants.

COMPONENTS- (Sessions 2&3) Page one depicts the format that will be used to summarize workshop discussions concerning the conceptual design for monitoring coastal ecosystem processes and components. Key tasks of workshop participants are to frame monitoring questions, identify ecosystem affectors or stressors, and identify candidate attributes or variables to monitor. An outline for salt marshes has been partially completed to depict the level of information desired.

LINKAGES- Identifies prospective partners and cooperators in monitoring of nearshore coastal ecosystems within the SWAN.

ECOLOGICAL PROFILES- Includes a draft coastal ecological profile of each park and preserve; a selected coastal bibliography; and maps depicting ecoregions, land status, and selected physical and biological data layers available for SWAN park units.

MAPS - Several overview maps have been included for reference.

WORKSHOP PARTICIPANTS

Armato, Peter
Ocean Science & Learning Center
Kenai Fjords National Park
PO Box 1727
Seward, AK 99664
907/224-2113
peter_armato@nps.gov

Bennett, Alan, Coordinator
Southwest Alaska Network
2525 Gambell St.
Anchorage, AK 99501
907/257-2628
alan_bennett@nps.gov

Byrd, Vernon
Alaska Maritime NWR
2355 Kachemak Dr., Suite 101
Homer, AK 99603
907/235-6546
vernon_byrd@usfws.gov

Hamon, Troy
Chief of Resources Management
Katmai National Park & Preserve
(Aniakchak/Alagnak)
King Salmon, AK 99613
907/246-2121
troy_hamon@nps.gov

Knuckles, Penny
Chief of Resources Management
Lake Clark National Park & Preserve
Port Alsworth, AK 99653
907/781-2113
penny_knuckles@nps.gov

Martin, Ian
Chief of Resources Management
Kenai Fjords National Park
PO Box 1727
Seward, AK 99664
907/224-2146
ian_martin@nps.gov

Mortenson, Dorothy, Data Manager
Southwest Alaska Network
2525 Gambell St.
Anchorage, AK 99501
907/257-2626
dorothy_mortenson@nps.gov

Oakley, Karen
Alaska Science Center
USGS-BRD
1011 East Tudor Rd
Anchorage, AK 99503
907/786-3579
karen_oakley@usgs.gov

Peterson, Charles (Pete)
Univ. of North Carolina, IMS
3431 Arendell St.
Morehead City, NC 28557
252/726-6841x130
cpeters@email.unc.edu

Schoch, Carl
Kachemak Bay NERR
Alaska Dept Fish & Game
2181 Kachemak Dr.
Homer, AK 99602
907/235-6377x2
carl_schoch@fishgame.state.ak.us

Sharman, Lewis
Glacier Bay National Park
Box 140
Gustavus, AK 99826
907/697-2645
lewis_sharman@nps.gov

Spencer, Page
NPS-Alaska Support Office
2525 Gambell St.
Anchorage, AK 99501
907/257-2625
page_spencer@nps.gov

BACKGROUND

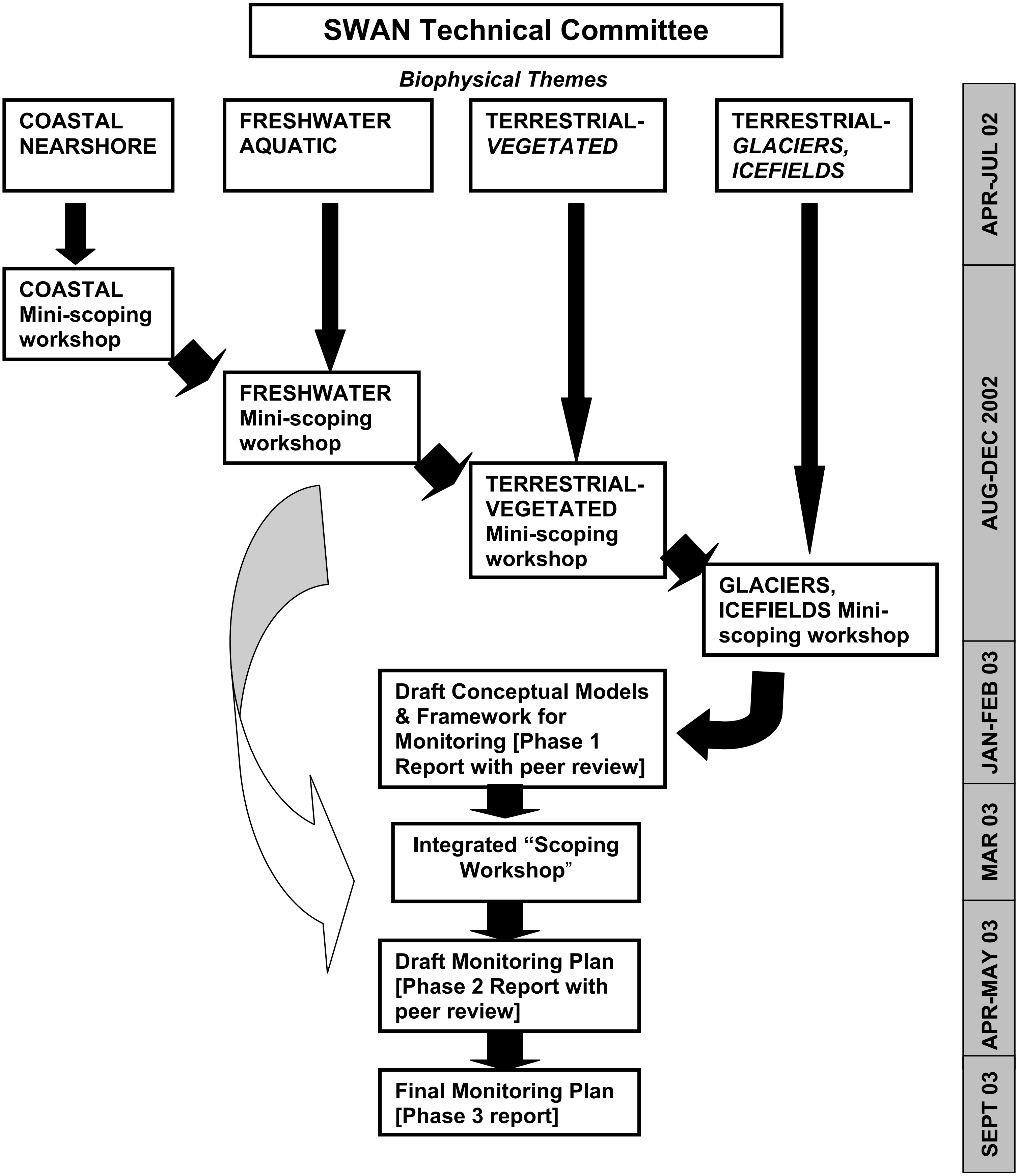
The National Park Service has implemented a strategy designed to institutionalize natural resource inventory and monitoring on a programmatic basis throughout the agency. The effort was undertaken to ensure that the approximately 270 park units with significant natural resources possess the resource information needed for effective, science-based managerial decision-making and resource protection. The national strategy consists of a framework having three major components: (1) completion of basic resource inventories upon which monitoring efforts can be based; (2) creation of experimental Prototype Monitoring Programs to evaluate alternative monitoring designs and strategies; and (3) implementation of operational monitoring of critical parameters (i.e. "vital signs") in all natural resource parks.

The overall goal of natural resource monitoring in parks is to develop scientifically sound information on the current status and long term trends in the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems. Use of monitoring information will increase confidence in manager's decisions and improve their ability to manage park resources, and will allow managers to confront and mitigate threats to the park and operate more effectively in legal and political arenas. To be effective, the monitoring program must be relevant to current management issues as well as anticipate future issues based on current and potential threats to park resources. The program must be scientifically credible, produce data of known quality that are accessible to managers and researchers in a timely manner, and be linked explicitly to management decision-making processes.

In Alaska, national park units have been assigned to 4 monitoring networks (See "Alaska Region Inventory & Monitoring Program Networks in Map Section). The southwest Alaska network (SWAN) consists of 5 units; Katmai National Park and Preserve (KATM), Alagnak Wild River (ALAG), Aniakchak National Monument and Preserve (ANIA), Lake Clark National Park and Preserve (LACL) and Kenai Fjords National Park (KEFJ). The timeline for designing the program and writing a monitoring plan is approximately 2 years (Fig 2). Natural resource staff from each of the parks and staff from the NPS Alaska Support Office comprise the core planning team, known as the Technical Committee (TC). This committee is chaired by the Network Coordinator and reports to the park superintendents.

The planning process is built around a series of mini-scoping workshops where the Technical Committee and scientists from other agencies collaborate in the identification of specific objectives and ecosystem attributes to monitor. The Coastal Workshop is the first of 3 or 4 subject area workshops to be held between August and December, 2002. In early 2003. a larger workshop will focus on developing an integrative and feasible sampling framework for biotic and abiotic resources in all systems (coastal, freshwater, and terrestrial) Beginning in 2004, the total projected annual operating budget for the SWAN monitoring program will be approximately 1.3 million dollars. All program costs including administration and salaries, data management, and operational monitoring must be supported by this budget.

Figure 1. Framework & Schedule for the Development of a Long-term Monitoring Plan - Southwest Alaska Network



Coastal Biophysical Features of the Southwest Alaska Network

The four Southwest Alaska Network (SWAN) coastal park units, Kenai Fjords, Lake Clark, Katmai, and Aniakchak, encompass approximately 1,200 miles of coastline along the Northern Gulf of Alaska extending from Resurrection Bay on the Kenai Peninsula to Kujulik Bay on the Alaska Peninsula. The western coastal boundary of the SWAN is formed in the north by the Alaska Range and to the south-southwest by the Aleutian Mountains.

This diverse coastal region is shaped by the moderating maritime influence of relatively warm ocean currents in the Northern Gulf of Alaska. The abrupt terrain adjacent to the sea culminates in high mountains that capture moisture from the oceanic air as rain and snow. At higher elevations, extensive ice fields feed glaciers that often reach the sea at the heads of fjords in the deeply incised shoreline. Annual precipitation is heaviest in the eastern side of the network but is highly variable locally because of irregular terrain. The Harding Ice field and glaciers on the Alaska Peninsula create substantial freshwater runoff that controls salinity in the nearshore waters.

Catastrophic events such as volcanic eruptions, landslides, and earthquakes periodically alter coastal riparian watersheds and intertidal habitats. Sediment dynamics and water movement resulting from freshwater runoff, currents, tidal action, and storms have a major influence on the spatial distribution and composition of nearshore biotic communities. Productivity of SWAN nearshore waters is influenced by the Alaska Coastal Current and variations in coastal geometry, seasonally changing winds, and coastal discharge. Because estuaries, bays, and fjords are directly connected to the ocean, everything from nutrients to consumers is exchanged between the two bodies of water.

The intertidal shorelines of the SWAN exhibit a wide range of habitat types. True soft-sediment flats and shores are not common, except in Cook Inlet. Marshes, fine-grained and coarse-grained sand beaches, and exposed and sheltered tidal flats represent approximately 15% of the coastline. Sheltered and exposed rocky shores, wave-cut platforms, and beaches with varying mixtures of sand, gravel, cobble, and boulders are the dominant habitats. Abundance, biomass, productivity, and diversity of intertidal communities is strongly related to distance from sources of runoff and glacier ice melt. Islands have richer intertidal communities than the mainland. Glacier ice melt depresses intertidal biotic communities by introducing turbidity and freshwater stresses.

There is a strong estuarine gradient across the Network. Fjord zones are very common and nearly all large rivers empty into fjords. A nearshore zone surrounds all the islets, islands and mainland, with a strong intertidal zone as the dominant interface between land and sea. Extreme wind and wave exposure occurs on the coastline of Kenai Fjords and Aniakchak whereas more protected coasts occur along the Lake Clark and Katmai Cook Inlet Coastline. Coastal riparian vegetation ranges from western hemlock and Sitka spruce rainforests in Kenai Fjords to alder-cottonwood shrub thicket at Aniakchak.

Natural Resource Management Issues

	Management Issues Identified at SWAN Parks	Marine/Coastal				Terrestrial-Vegetated Zone				Terrestrial - Rock&Ice				Freshwater Aquatics			
		ANIA	KATM	KEFJ	LACL	ANIA	KATM	KEFJ	LACL	ANIA	KATM	KEFJ	LACL	ANIA	KATM	KEFJ	LACL
	Pollution																
1	Oil and gas transport & storage	X	X	X	X							X		X	X	X	
2	Airborne pollution or visibility			X	X			X	X	X	X	X	X			X	X
3	Noise pollution			X	X			X	X			X	X				X
4	Sewage or human wastes			X				X				X		X	X	X	X
5	Water pollution from motorized vehicles				X									X	X		X
6	Light pollution			X				X				X					
7	Debris and dumping from fishing activities				X												
	Biological Resources																
1	Habitat fragmentation	X	X	X	X	X	X	X	X			X					
2	Loss of community diversity			X	X	X	X	X				X				X	X
3	Wildlife disturbance and displacement			X	X	X	X	X				X				X	
4	Exotic species introductions			X		X	X	X	X			X		X	X		
5	Introduction of diseases			X													
6	Population decline in shorebirds/harlequin ducks	X	X		X												
7	Sustainable population of fish													X	X	X	X
8	Trophic interactions in large lake systems													X	X		X
9	Long-term affects on salmon populations on terrestrial ecosystems.																X
10	Insect outbreaks			X		X	X	X	X								
11	Human impact on Pinipeds	X	X	X													
12	Poaching					X	X										
13	Lack of knowledge on the health of furbearers population	X	X			X	X										

As of July 2002

Natural Resource Management Issues

	Management Issues Identified at SWAN Parks	Marine/Coastal				Terrestrial-Vegetated Zone				Terrestrial - Rock&Ice				Freshwater Aquatics			
		ANIA	KATM	KEFJ	LACL	ANIA	KATM	KEFJ	LACL	ANIA	KATM	KEFJ	LACL	ANIA	KATM	KEFJ	LACL
14	Lack of knowledge on the large mammal population					X	X										
15	Raptor populations and trends								X								
16	Impact on shorelines	X	X	X	X											X	X
17	Long-term vegetation community composition and structure				X				X								
18	Relationship of lichen to environment and animals								X								
19	Wildlife mortality due to roadkill							X									
20	General health of aquatic ecosystems																X
21	Composition, structure and function of intertidal biota				X												
22	Potential risk to rare plants								X								
23	Natural predator/prey systems being maintained					X	X		X								
24	Baterial levels in fresh waters													X	X	X	
	Commercial Human Use																
1	Commercial Fishing			X	X									X	X		
2	Settlement impact			X	X											X	
3	Port/Access Development				X									X	X		
4	Logging				X												
5	Tour Boats			X	X									X	X		
6	Aquaculture			X	X												
7	Vessel traffic			X	X	X	X							X	X		
8	Small aircraft				X	X	X							X	X		
	Other Human Use																
1	Camping			X	X	X	X		X								
2	ATV Activity					X	X										

As of July 2002

Natural Resource Management Issues

	Management Issues Identified at SWAN Parks	Marine/Coastal				Terrestrial-Vegetated Zone				Terrestrial - Rock&Ice				Freshwater Aquatics			
		ANIA	KATM	KEFJ	LACL	ANIA	KATM	KEFJ	LACL	ANIA	KATM	KEFJ	LACL	ANIA	KATM	KEFJ	LACL
3	Sport hunting/fishing				X	X	X		X					X	X	X	X
4	Subsistence impact on wildlife populations				X	X	X		X								
5	wildlife-viewing (bears, marine mammals)	X	X			X	X		X								
6	Number of campsites and social trails changing			X		X	X	X				X					
7	Secondary impacts of wood cutting			X					X								
8	Snowmachine use											X		X			
9	Vehicles				X												
10	Resource extraction (mining)				X											X	X
	Physical Change																
1	Soil erosion			X	X	X	X	X				X				X	
2	Change in sea level			X													
3	Change in water temperature			X													X
4	Change in Climate			X	X	X	X	X	X			X	X			X	X
5	Glacier Changes				X				X			X	X				X
6	Wildfire							X								X	
7	Change in water chemistry															X	
8	Volcanic eruptions				X				X				X				X
9	Soil temperature				X				X				X				X
10	Permafrost changes				X				X				X				X
11	Altered precipitation patterns											X					
12	Meteorology												X				

Summary of Coastal Monitoring by NPS
In Gulf of Alaska Park Units

	SWAN				SEAN*			CAN*
On-going Monitoring Using Established Protocols	**ANIA**	**KATM**	**KEFJ**	**LACL**	**GLBA**	**SITK**	**KLGO**	**WRST**
PHYSICAL								
Basic oceanographic parameters					X			
INVERTEBRATES								
Dungeness crabs (population index)					X			
Marine vertebrate predators (populations - seabirds/marine mammals only)					X			
Rocky (unconsolidated) intertidal biota - populations					X	X		
Shallow subtidal benthic biota (populations, animals and macroalgae, hard and soft bottom)					X			
BIRDS								
Black-legged kittiwakes (population and productivity at established colonies)								
Bald eagles (nests - active/inactive & productivity)		X	X	X	X			
Black Oystercatcher productivity			X					
MAMMALS								
Humpback whales (population index)					X			
Harbor seals (population at haulouts and pupping areas - productivity)			X		X			X
Steller sea lions (population at established haulouts - productivity at one site)					X			
Seal/sea lion vessel disturbance behavior					X			
Sea otters (population index)					X			
FISH								
Commercial fisheries (several species - harvest/effort)					X			
HUMAN EFFECTS								
Cruise ship stack emissions					X			
Campsites			X					

* Other Alaska Region Networks with Gulf of Alaska Coast:

SEAN - Southeast Alaska Network
Glacier Bay National Park (GLBA)
Sitka Historical Park (SITK)
Klondike Gold Rush (KLGO)

CAN - Central Alaska Network
Wrangell-St. Elias National Park & Preserve (WRST)

As of July 2002

Southwest Alaska Network
Vital Signs Monitoring
Mandates, Goals, Objectives

NPS Mandate:- " . .to preserve for the benefit, use, and inspiration of present and future generations . . ". .

SWAN Park and Preserve Mandates - . . to maintain unimpaired the scenic and environmental integrity of icefields, glaciers, volcanos, coastal fjords, watersheds, wild rivers, lakes, waterfalls, and alpine meadows in their natural state; and to protect birds, fish, terrestrial mammals, salmon, seals, sea lions, other marine wildlife and their habitats in their natural state . ."

Protect and Manage Natural Resources

Maintain landscape features, ecosystems, communities, populations, trophic structure, and productivity within the historic bounds of natural variability

Understand Natural Resources and Ecosystem Dynamics

Conduct Long-term Monitoring

Conduct Resource Inventories

NPS Service-wide Vital Signs Monitoring Goals

1. Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.

2. Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.

3. Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.

4. Provide data to meet certain legal and congressional mandates related to natural resource protection and visitor enjoyment.

5. Provide a means of measuring progress towards performance goals

Goals & Objectives
Coastal Ecosystem Monitoring - SWAN

***Overall Network Goals**: I. Establish baseline ecological conditions representing the current status of park and preserve ecosystems; and*
II. Detect changes over time, particularly, any changes that are outside the natural variation in these baselines.

Coastal Goal I. **Understand how park and preserve coastal nearshore ecosystems are structured.**

Objective A. **Apply a standard coastal mapping and classification system for physical features and biotic resources**

Objective B. . . .

Coastal Goal II. **Understand how park and preserve coastal nearshore ecosystems work.**

Objective A. **Monitor dominant physical processes that control or modify the nearshore environment**

Objective B. . . .

Coastal Goal III. **Understand how park and preserve coastal nearshore ecosystems are influenced by humans.**

Objective A. **Monitor patterns of occurrence, concentration, and transport of contaminants in sediments and biota**

Objective B. . . .

Monitoring Framework Requirements*

- Ecologically-based issues-oriented with emphasis on assessing long-term and cumulative effects rather than short-term and isolated effects
- Incorporates work from multiple disciplines (e.g., biology, hydrology, geomorphology, and landscape ecology) and at multiple scales (e.g., coarser-grained network-scale, and finer-grained park-scale,)
- Blends "top-down," integrative approach for characterizing ecological systems, with "bottom-up" understanding of ecosystem processes and functions
- Focuses on forces known to shape park ecosystems (natural disturbance, human use, climate, physiography, and biotic interactions) and on components that are sensitive to change

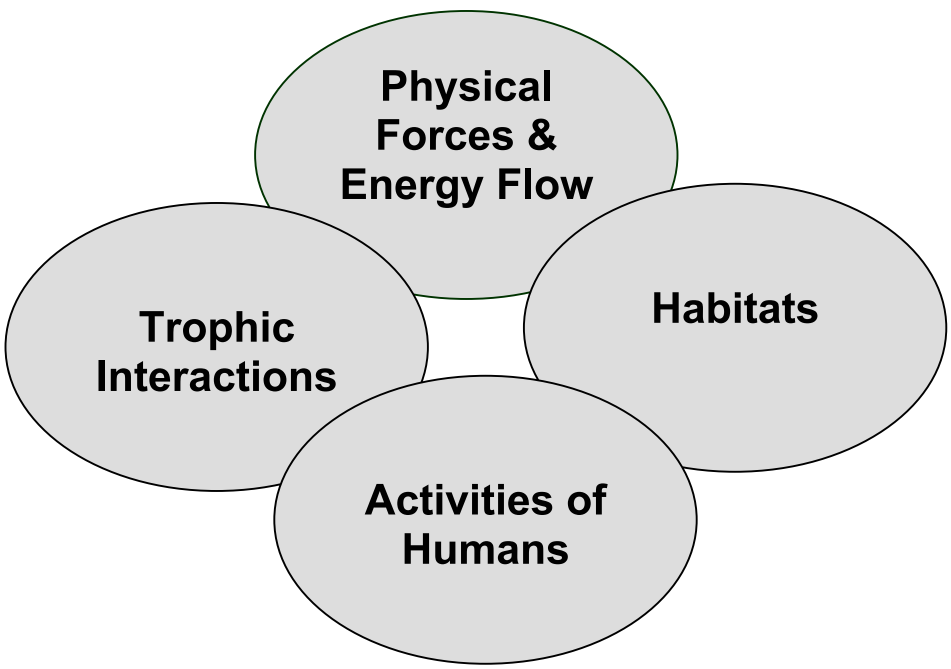
**Defined by SWAN Technical Committee*

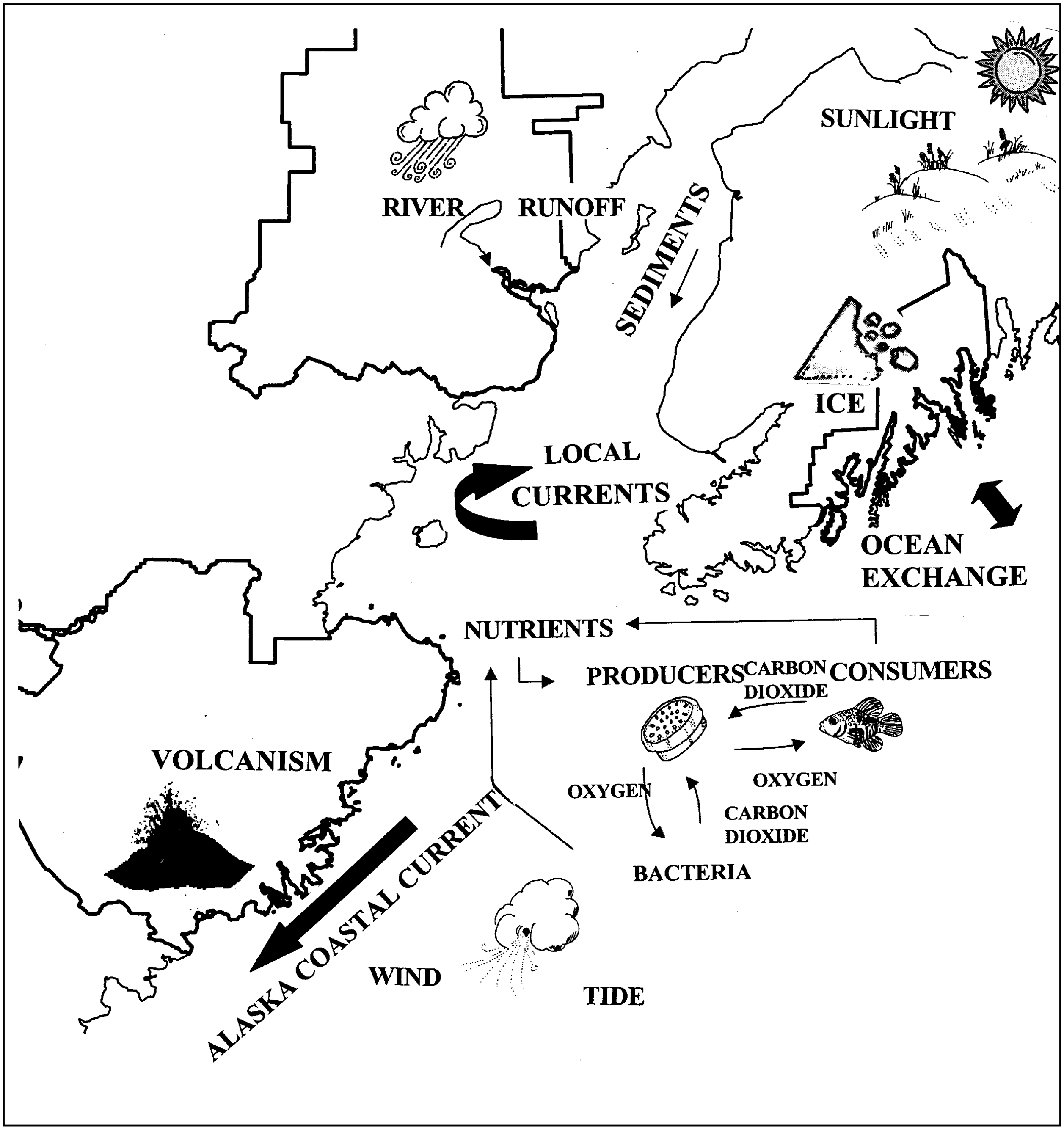
Criteria for selection of attributes ("vital signs") to monitor (modified from Dale and Beyeler 2001)

- ***Be easily measured***. The attribute should be straightforward and relatively inexpensive to measure
- ***Wide distribution over an ecoregion, park unit or the network***
- ***Be sensitive to stresses on the system.*** Responsive to stresses placed on the system by human actions while also having limited and documented sensitivity to natural variation
- ***Respond to stress in a predictable manner.*** Have a known response to disturbances, human-induced stresses, and changes over time.
- ***Have low variability in response***. Attributes that have a small range in response to particular stresses allow for changes in the response value to be better distinguished from background variability
- ***Be integrative.*** The full suite of attributes provides a measure of coverage of the key gradients across the ecological systems (e.g. gradients across soils, vegetation types, temperature, space, time, etc.)
- ***Be anticipatory***. Signify an impending change in key characteristics of the ecological system

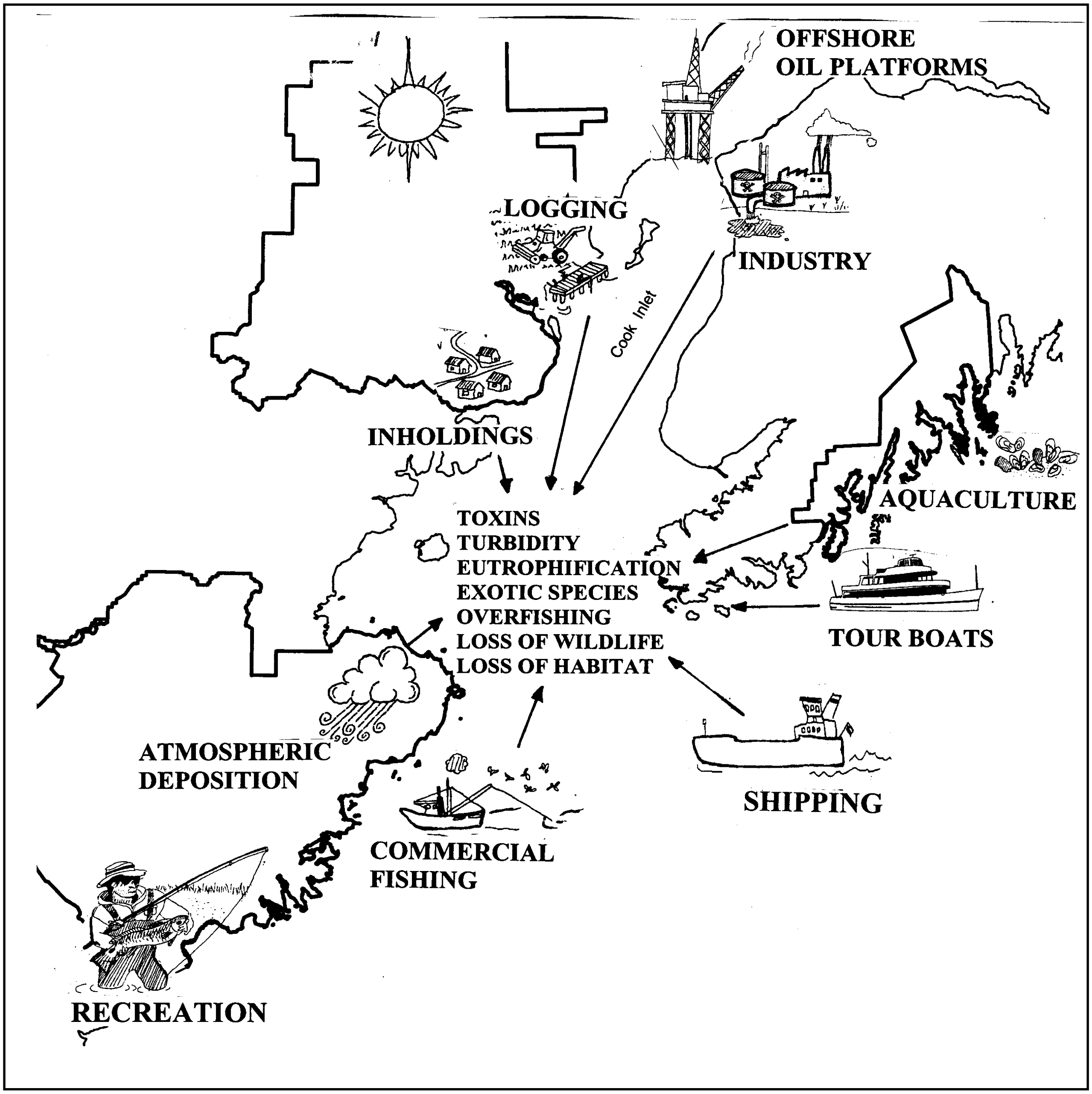
DRAFT CONCEPTUAL MODEL
SWAN COASTAL ECOSYSTEM

The SWAN conceptual models depict mechanistic relationships among biotic, abiotic, and anthropogenic components and linkages in a schematic format. Models were developed to assist in identifying important issues confronting coastal ecosystems, and ultimately, to assist with selection of specific attributes to monitor. We used a series of hierarchical models to avoid producing one figure with an indecipherable amount of information on it. We elected to mix the standard 'energy flow circuit' with a pictorial format, which should be relatively easy for people from any background to understand. Pictorial models are described in 'summaries' that follow the illustration and describe principles of the interactions within ecosystems.

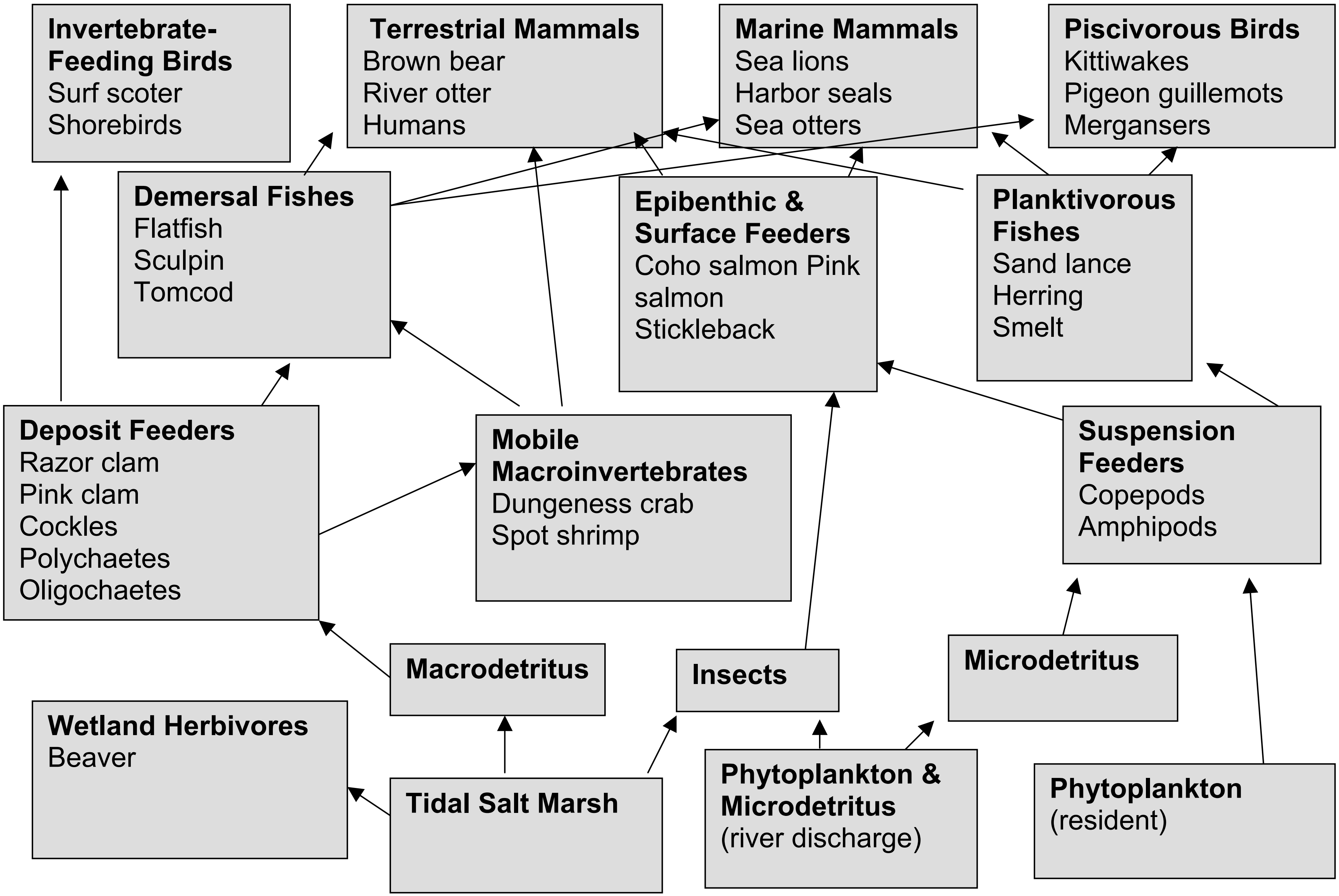




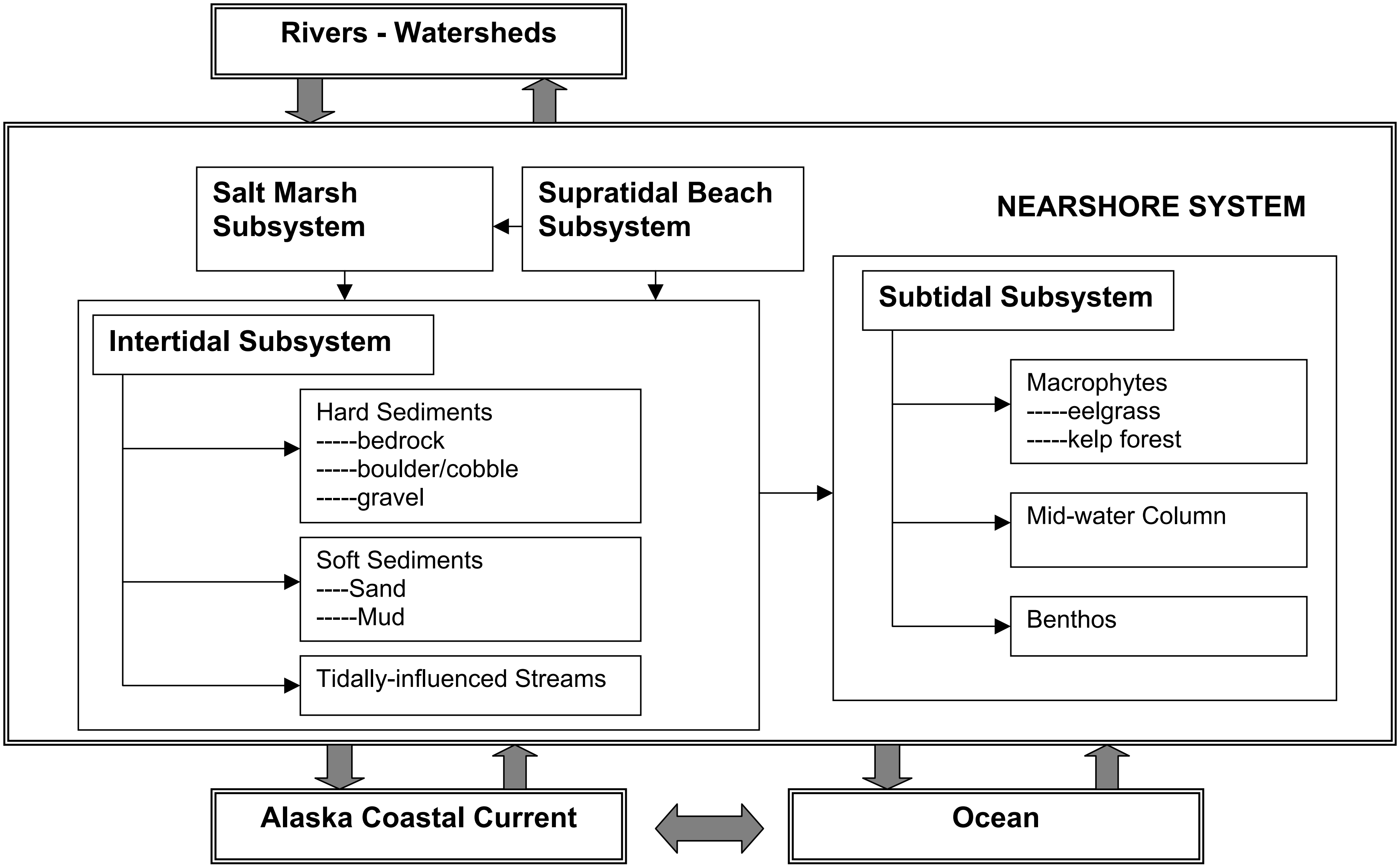
Physical Forces and Energy Flow. Catastrophic events such as volcanic eruptions, landslides, and earthquakes periodically alter coastal riparian watersheds and intertidal habitats. Sediment dynamics and water movement resulting from freshwater runoff, currents, tidal action, and storms have a major influence on the spatial distribution and composition of nearshore biotic communities. Productivity of SWAN nearshore waters is influenced by the Alaska Coastal Current and variations in coastal geomorphology, seasonally changing winds, and coastal discharge. Because SWAN estuaries, bays, and fjords are directly connected to the ocean, everything from nutrients to consumers is exchanged between the two bodies of water.



Activities of Humans. Human actions can have local and widespread effects on the productivity and diversity of SWAN coastal ecosystems. Oil extraction, storage, refining, and transport can introduce toxins to the air or water that can stress or kill marine, estuarine, and terrestrial species. Logging, mining, and other commercial activities on adjacent private lands and inholdings can destroy habitats, displace wildlife, increase turbidity, and introduce nutrients. Commercial fishing can deplete prey species of marine mammals, seabirds, and brown bears or disrupt trophic interactions by removing too many top predators. Nearshore vessel traffic and recreation can scar seagrass beds, leak fuel, deposit debris on beaches, and displace birds and mammals.



Trophic Interactions. Simplified representation of major linkages between trophic groups in SWAN nearshore coastal ecosystems.



Nearshore Habitat Typology of SWAN Coastal Ecosystems. In addition to energy flow and trophic interactions, coastal ecosystems can be characterized by defining habitats. Habitats are the elements of an environment that sustain an organism or a specific community of organisms. Energy can be transferred among habitats by physical movement of the water, or by movement of organisms between habitats. The interaction among habitats is partly responsible for maintaining trophic structure and productivity of the nearshore coastal system.

Agents of Change in SWAN Nearshore Coastal Ecosystems.

Agents of change are mechanisms defined as natural processes and events, or human activities. Agents of change can operate within the range of natural variability and acceptable limits of change or they may not. If not, they are "stressors."

Key Processes or "Stressors"		**Potential Ecological Effects**
1. <u>Hydrologic/Hydrodynamic</u> freshwater inflow timing, quantity distribution tides and currents	→	- change in peak storm runoff - frequency/severity of flooding - altered stream velocities - accelerated streambank erosion - altered salinity
2. <u>Sediment Dynamics</u> supply erosion, transport	→	- disruption of sediment balance - landslides - reduction in habitat complexity - increase in fine sediment load - blockage of spawning areas
3. <u>Geomorphology/Tectonics</u> earthquakes volcanic eruptions uplift	→	- loss/alteration of fish/shellfish habitat - loss/alteration of salt marshes - decreased channel sinuosity
4. <u>Water Chemistry</u> temperature pH salinity nutrients	→	-decreased fish survival - increased bod - increased sediment associated toxics, suspended solids - euthropication - expanded temperature extremes
5. <u>Biotic Interactions</u> predator/prey herbivery invading species	→	- alteration of ecological processes - altered trophic structure - disruption of migration pattern
6. <u>Human use</u> commercial recreational logging oil transport/storage aquaculture	→	- shifts in species composition and abundances - depletion of key resources - loss/alteration or contamination of fish/shellfish habitat

NAME ________________________

Prospective Outline for Workshop Discussions (Sessions 2 & 3)

Nearshore Coastal Component or Process:

Monitoring Questions/Objectives:

What to Monitor:

Affectors (Stressors) and Related Factors:

Justification and other Information:

Potential Partners:

Prospective Outline for Workshop Discussions (Sessions 2 & 3)

EXAMPLE

Nearshore Coastal Component or Process: Tidal Salt Marshes

Monitoring Questions/Objectives: Is the surface elevation of salt marshes rising or sinking relative to sea level? Is salt marsh slough erosion and recession reducing number and area of tidal ponds? Is salt marsh plant species composition changing or are vegetation zones migrating?

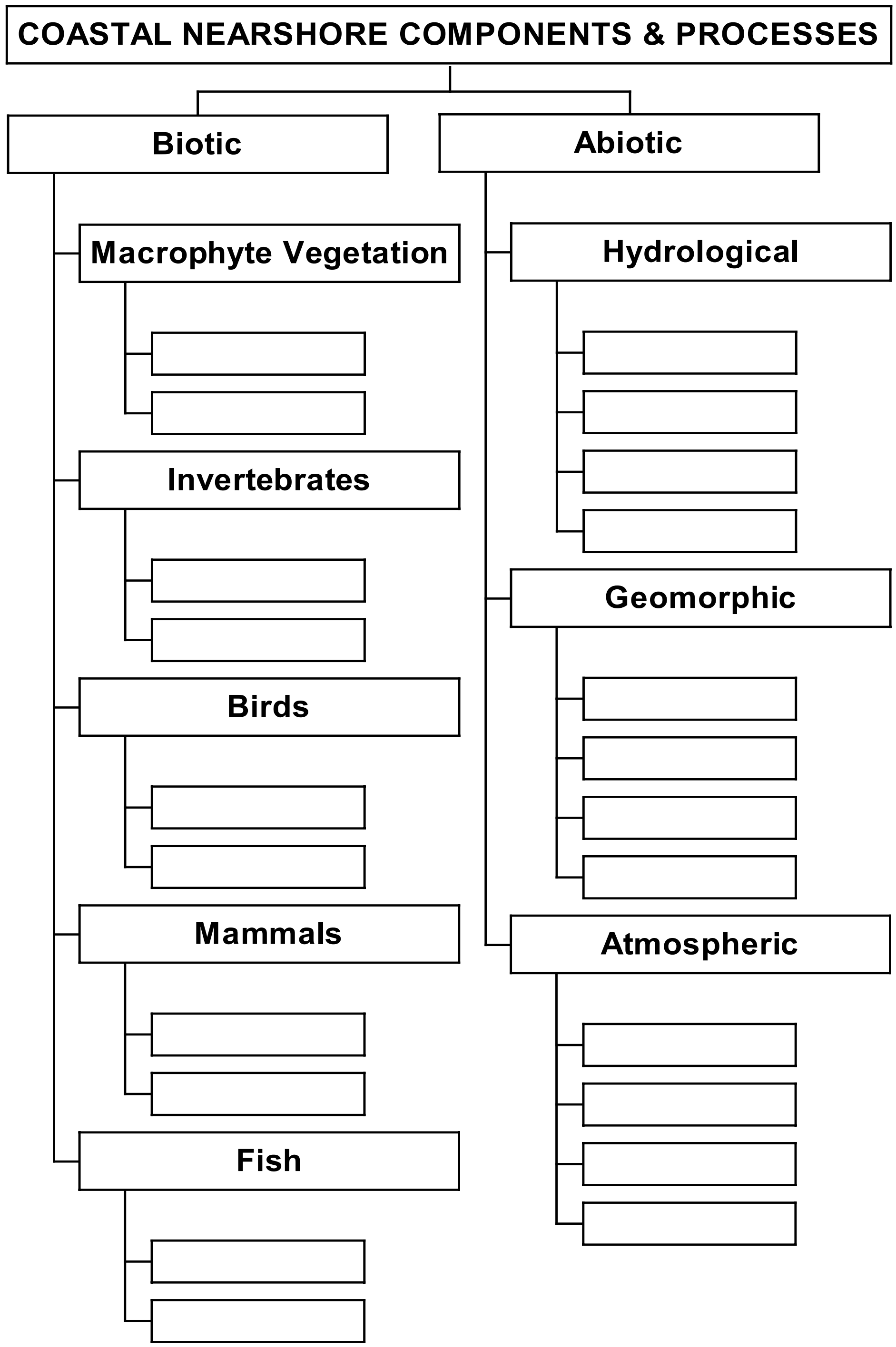
Affectors (Stressors) and Related Factors: Alterations in hydrology, sediment supply, tidal inundation, sea level, salinity, air temperature, and marsh vegetation production. Off road recreational vehicles (ORV's) may kill vegetation and create deep ruts that modify drainage patterns, and create zones of hypersalinity (through submergence).

What to Monitor:
- Air temperature and precipitation
- Salt marsh surface elevation, rates of vertical accretion
- Tidal inundation
- Spatial configuration of sloughs
- Salinity
- Salt marsh plant zonation

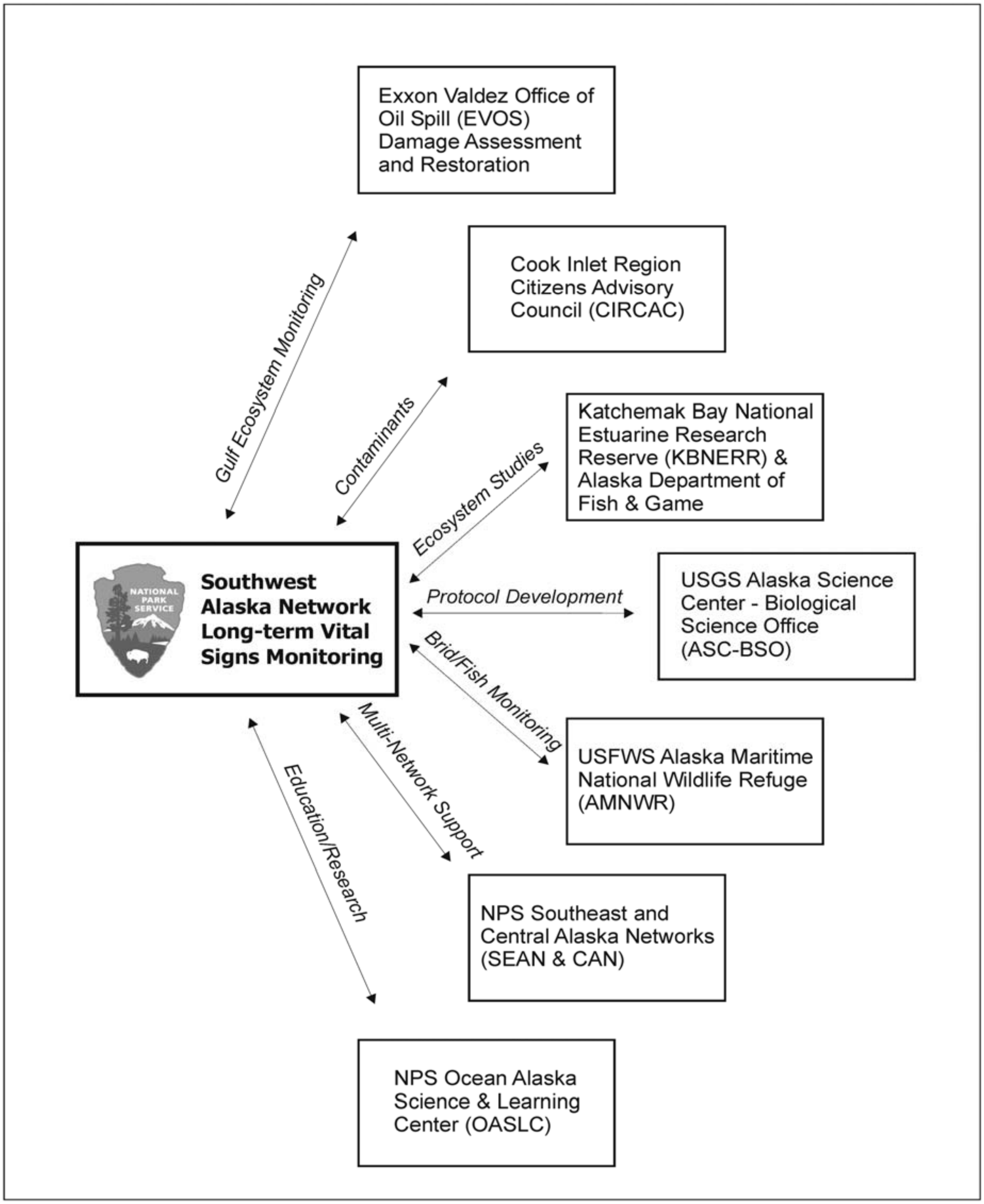
Justification and Other Information:
Meteorological elements and tidal inundations are the major driving forces for physical and biological processes in salt marshes. Semidiurnal flooding during high tidal events cause pond/mudflat inundation and drives surface hydrology. Sedimentary processes and system dynamics are important because they affect the timing and distribution of tidal flooding and associated pond/mudflat sedimentation. Tidal creek dynamics are capable of causing rapid changes in surface hydrology. Salinity gradients control the distribution of plant species.

Potential Partners:

Candidate Attributes For Long-term Monitoring
Southwest Alaska Network



Principle Linkages and Partnerships for Long-term Monitoring in the Nearshore Coastal Ecosystem Northern Gulf of Alaska



EVOS

The Exxon Valdez Office of Oil Spill (EVOS) Damage Assessment and Restoration manages research and monitoring projects for the Exxon Valdez Trustee Council. Several National Oceanic and Atmospheric Administration (NOAA) agencies are involved in these research and monitoring efforts including the Auke Bay Laboratory (ABL), National Marine Fisheries Service (NMFS), and many contractors. NOAA is represented on the Exxon Valdez Trustee Council by the Alaska Regional Administrator of the National Marine Fisheries Service.

The EVOS Northern Gulf of Alaska study area extends from eastern Prince William Sound to the western edge of the Alaska Peninsula and include coastal lands of all Park Units with the SWAN. EVOS research and monitoring is directed at offshore and nearshore marine waters, estuarine, freshwater and terrestrial environments and the interaction of geologic, climatic, oceanographic, and biologic processes.

Monitoring Programs

In October 2002 EVOS will initiate the Alaska Ecosystem Monitoring and Research (GEM) program, a long-term commitment to gathering information about the physical and biological components that make up this world-renowned marine ecosystem. What makes GEM unique is that it incorporates interagency cooperation and collaboration, public involvement and accessible, informative data and information on the Gulf of Alaska ecosystem.

The flagship of the GEM program will be a core monitoring program, which, when combined with the monitoring efforts of other resource agencies and research entities, will help detect environmental change over time and greatly expand understanding of the Gulf of Alaska ecosystems. The program will also include short- and long-term research using the latest technological breakthroughs in marine science. With these, the GEM program will provide a better understanding of the complex processes in the ocean.

CIRCAC

The Cook Inlet Region Citizens Advisory Council (CIRCAC), created by the Oil Pollution Act of 1990 and funded by industry, has a federal mandate to monitor for environmental impacts of oil-related activities in Cook Inlet including coastal areas of Lake Clark and Katmai National Parks. It focuses on monitoring for petroleum hydrocarbons throughout the inlet.

Monitoring Programs

Major focus is to collect intertidal data that would aid in assessing effects of an acute impact, such as an oil spill. The intertidal zone is the area most damaged by nearshore oil spills and the existing intertidal data for Cook Inlet are not adequate for characterizing abundance and variation in biological resources or hydrocarbons. The major steps that will be taken by the CIRCAC are:

- Establish a baseline program for Cook Inlet beaches that are most likely to be exposed to crude oil from a catastrophic oil spill.
- Identify the most suitable target species for use as sentinel organisms, e.g., razor clams on sand beaches, deposit-feeding clams on mud flats, and blue mussels on rocky shores.
- Analyze intertidal sediments and organism tissues for hydrocarbon concentrations.

KBNERR

The Kachemak Bay National Estuarine Research Reserve (KBNERR) is managed by the Alaska Department of Fish and Game in cooperation with the Alaska Department of Natural Resources. Kachemak Bay is a long, wedge-shaped estuary in south central Alaska that is approximately 39 miles long and 24 miles wide adjacent to Lake Clark and Kenai Fjords National Parks. Goals of KBNERR are to conduct long-term research and monitoring to gain a better scientific understanding of natural and human processes occurring in Kachemak Bay watershed and estuarine ecosystem for use in coastal decision making.
.

Monitoring Programs
A primary objective of the Kachemak Bay Research Reserve is to monitor changes in the bay and determine the mechanisms causing those changes by linking monitoring with process-oriented experiments. Current monitoring is focused on temporal and spatial distribution patterns of marine organisms such as kelp forests, intertidal and subtidal rocky shore algae, invertebrates, marine birds, shorebirds, marine mammals, and fishes. Fixed station ocean sensors are used to measure seawater temperature, water quality, pH, salinity, dissolved oxygen, sedimentation rates, and chlorophyll fluorescence. Measurements at fixed stations are augmented spatially by CTD transects along the across the axis of the bay.

USGS-ASC/BSO

As the lead biological science agency for the Department of the Interior (DOI) in Alaska, the *Alaska Science Center - Biological Science Office* is responsible for research trust lands and waters (including those of the National Park Service, Fish and Wildlife Service, Bureau of Land Management, and Minerals Management Service) and DOI trust species (including migratory birds, marine mammals, and anadromous fish) in Alaska, providing scientific information essential for resource management decisions.

Monitoring Programs
Alaska Biological Science Center and the Alaska Maritime National Wildlife Refuge are doing a long-term ecosystem study on seabird population dynamics and forage fish in lower Cook Inlet, funded by the EVOS Trustee Council. Development of coastal monitoring protocols & process-based studies to address landscape-scale variation in coastal communities of certain national parks in Alaska. ASC-BSO is developing detailed, scientifically credible methods for long-term monitoring of the rocky intertidal zone to help Park resource managers detect both human-induced and natural changes In cooperation with the National Park Service, ASC-BSO is conducting a number of research projects in Glacier Bay National Park and Preserve including oceanography, benthic marine fisheries population ecology, and sea otter colonization.

AMNWR

The Alaska Maritime National Wildlife Refuge (AMNWR) is managed by the U.S. Fish and Wildlife Service. It consists of more than 2,400 islands, headlands, rocks, islets, spires and reefs of the Alaskan coast. The refuge stretches from Cape Lisburne on the Chukchi Sea to the tip of the Aleutians and eastward to Forrester Island on the border of British Columbia.

Monitoring Programs
Long-term data is collected annually for selected species of marine birds at breeding colonies to monitor the condition of the marine ecosystem and to evaluate the conservation status of species under the trust of the Fish and Wildlife Service. The strategy for colony monitoring includes estimating timing of nesting events, rates of reproductive success (e.g., chicks per nest), population trends and diet composition of representative species of various foraging guilds (e.g., off-shore diving fish-feeders, offshore surface-feeding fish-feeders, diving plankton-feeders) at geographically-dispersed breeding sites. This information enables managers to better understand ecosystem processes and respond appropriately to resource issues. It also provides a basis for researchers to test hypotheses about ecosystem change. The value of the marine bird monitoring program is enhanced by having sufficiently long time-series to describe patterns for these long-lived species.

SEAN/CAN

The Southeast and Central Alaska Networks (SEAN/CAN) of the Alaska Region include four coastal national park units on the northern Gulf of Alaska; Wrangell-St. Elias National Park and Preserve, Glacier Bay National Park, Sitka National Historic Park, and Klondike Gold Rush National Historic Park. Although most ecological monitoring will be implemented on a network-wide basis, three Alaska networks have a unique opportunity to collaborate in monitoring Gulf of Alaska coastal ecosystems. The three networks may function as a team and share professional expertise, monitoring protocols, and data management strategies.

OASLC

The Ocean Alaska Science & Learning Center (OASLC) is based in Seward at Kenai Fjords National Park and the Alaska SeaLife Center. It was established in October 2000 as part of a national network of Natural Resource Challenge Learning Centers. The OASLC is a partnership dedicated to understanding and preserving the marine ecosystem connecting Alaska's National Parks through research and education. As such, the OASLC will help support and encourage more research in Alaska's eleven coastal National Parks and will provide education programs based on these research projects.

Goals of the OASLC include:
- Foster sustainable ecosystem policies through science and education.
- Explain resource issues in terms understood by wide audiences and in ways that encourage participation.
- Provide adequate scientific information to manage resources.
- Foster partnerships and opportunities for other agencies and institutions to participate in marine research and education.
- Provide the public with the opportunity to participate in the research process.
- Establish distance learning programs to educate state, national, and international audiences about Alaska's marine issues.
- Build and maintain physical and organizational infrastructure necessary to achieve mission.

Ecological Profile (Draft)
Katmai National Park and Preserve-
Shelikof Strait/Kamishak Bay Coastline

Physical Environment - The Katmai National Park and Preserve coastline extends from the mouth of the Kamishak River in Kamishak Bay to Cape Kubugakli in Shelikof Strait. The dominant feature is the Shelikof Strait coastline, a complex of narrow fjords, island and seastack bays, sandy beaches, and rocky headlands. The Strait is a southwest continuation of Cook Inlet extending approximately 170 miles to a juncture with the waters of the North Pacific Ocean. This complex ecosystem includes river drainages, salt marshes, beaches, intertidal zones, estuaries, coastal uplands, and islands.

In contrast, the shoreline of Kamishak Bay has a rather monotonous appearance. At low tide, vast mudflats extend up to 6 miles offshore interspersed with scattered rock outcrops and headlands. Higher on the beach, large slabs of sandstone are scattered around like huge flagstones. Nordyke Island is the largest of these. Although outside the boundary of the Park and Preserve, Augustine Island dominates the seascape in Kamishak Bay. Because glaciers comprise 216,000 acres (6%) of Katmai, the coastal region is strongly influenced by vast quantities of silty freshwater during the summer months. Turbidity patterns can vary locally. For example, northern Kamishak Bay is much clearer than southern Kamishak Bay (Suchanek 1994).

The Katmai coastline experiences a characteristic maritime climate. The North Pacific high pressure system dominates the area during the summer, bringing south to southwest winds and typical average air temperatures ranging from 50-54 degrees Fahrenheit. In winter, the weather is controlled by the Aleutian low atmospheric pressure system. Winds associated with this system are generally north to northwesterly, resulting in low temperatures at or below freezing. Summer winds tend to be slightly higher than in winter and are more consistent in direction. Shelikof Strait is bounded by mountains on the north and south and can be subjected to high winds related to the funneling of air between these mountain ranges.

The entire coastline has been shaped by glaciation, with long, narrow fjords and U-shaped valleys. Ice scour and moraine deposits in Shelikof Strait attest to the fact that ice completely filled the Strait and spilled out onto the Continental Shelf during past glacial advances. The Strait lies perpendicular to the mountains and geologic fault lines. Typically rivers enter at the heads of the fjords and are characterized by shorter, wider estuarine embayments. Exposed bedrock and shallow soils prevail on headlands and islands. The seafloor in Shelikof Strait is broad and generally flat with closed basins. Along the south side of the Alaska Peninsula, Shelikof Strait has relatively steep slopes descending over 190 meters in the south; areas of deepest water in Shelikof Strait occur along the southeastern side adjacent to Kodiak Island where they reach to depths of 240 meters.

Coastal freshwater streams and rivers are characteristically short, with steep gradients. One exception is the Katmai River, which was impacted by volcanic ash deposited from the 1912 eruption of Novarupta. The heavy silt loads from the ash-laden watershed transformed this single channel system into a three-mile-wide braided river. Other major systems are the Kamishak River, Little Kamishak River, Strike Creek, and Douglas River that flow into Kamishak Bay. Numerous named (e.g., Katmai River, Alagogshak Creek) and unnamed streams flow down the characteristically short, steep drainage along the Shelikof Strait coastline (U.S. National Park Service, 1994). The streams that empty into the bays along the Shelikof Strait coastline are 3-20 miles in length.

There are several small freshwater lakes located along the Shelikof Strait coast. These coastal lakes are much smaller than those found in the park north of the Aleutian Range. Heard et al. (1969) believes that most lakes along KATM's coast are glacial in origin and are relatively deep for their size. Dakavak Lake is the largest coastal lake, approximately 2.8 miles long and 0.6 miles wide (1.7 mi^2) with a depth greater than 69 feet.

***Biological Resources* -** Offshore areas support a highly productive marine ecosystem, rich with intertidal, benthic, and pelagic plant and animal life which sustains extensive populations of marine and anadromous finfish, shellfish, seabirds, and marine mammals. Rocky shorelines and cliffs provide nesting areas for seabirds and pupping/haul-out areas for seals and sea lions. Seabirds, shorebirds, and waterfowl utilize nearshore intertidal areas for breeding, staging, or feeding. Coastal riparian vegetation is typically alder and grass with scattered stands of balsam polar and Sitka Spruce.

Key ecological features of the Katmai Coastline include: sheltered salt marshes and tidal flats that support lush brackish vegetation, large populations of benthic organisms, and serve as important feeding and resting areas for brown bears (*Ursus arctos*), birds, and fish; eelgrass and kelp beds that provide herring spawning areas and a nursery substrate that supports the base of the nearshore food chain; and tidally-influenced coastal freshwater streams that support wild stocks of anadromous salmon.

Black-legged kittiwakes (*Rissa tridactyla*), tufted puffins (*Fratercula cirrhata)*, horned puffins (*F. corniculata*), Glaucus-winged Gulls (*Larus glaucescens)***,** and Pigeon Guillemots (*Cepphus columba*) are the dominant breeding seabirds. Twenty-eight colonies have been identified but *a*pproximately 70% of the seabirds nest on Ninagiak and Shaw Islands (Bailey and Faust 1984). Cliff-nesting cormorants (*Phalacrocorax sp.)* and kittiwakes concentrate at five locations: Shakun, Kukak, Gull, Takli, and Katmai (Goatcher 1994). Harlequin ducks (*Histrionicus histrionicus*) occur along most of the Katmai coastline. Martin (1989) reported 1,360 Harlequins during population counts in summer 1989 and Goatcher (1994) reported 1,646 in 1994.

Sea otters *(Enhydra lutris)* occur along most of the Katmai coastline and are most numerous near Douglas Reef, Kiukpalik Island, Nukshak Island and Shakun Reef (Herendeen 1989). Estimates of sea otter abundance have ranged from 400-600 in 1989 (Herendeen 1989) to 130 in 1993 (Pots et al. 1993). Harbor seals (*Phoca vitulina)* occur along in all the bays and haulout on nearshore reefs and islands. Steller sea lions *(Eumetopias jubatu*s), a federally-listed threatened species, use most of the Katmai coastline. Although the park's coastal waters are relatively shallow, beluga whales *(Balaena mysticetu*s), fin whales *(Balaenoptera physalu*s), and humpback whales *(Megaptera novaeanglia*e) regularly occur offshore and in bays (Goatcher, pers comm).

Clearly, brown bears are a "signature" resource of the Katmai Coastline. Katmai and adjacent areas of the Alaska Peninsula supports the largest, unexploited populations of brown bears in the world (Sellers and Miller 1994). Bears reach their highest densities along the eastern coastline where nutrients and resources are abundant, and temporally and spatially stable (Smith 1996). Bears forage on coastal sedge flats at Swikshak, Chiniak, Hallo Bay, and Kukak Bay.

NPS Natural Resource Inventories and Monitoring - Few comprehensive inventories or sustained monitoring projects have been conducted along the Katmai Coastline. Most biological surveys for seabirds and marine mammals can be characterized as opportunistic counts of selected areas. Most of these opportunistic counts involved post-EVOS aerial surveys that attempted to record multiple bird and mammal species simultaneously and are fraught with high observer bias and variability.

In 1991, the NPS received funding to study the oil-related impacts on the coastal environments. The objective of this study was to determine the relative physical and chemical degradation rates of stranded oil mousse on Gulf of Alaska beaches and to correlate the degradation rate with geomorphological controls such as: energy regime, slope, aspect, substrate particle composition (Schoch, 1993). In association with this work, the U.S. National Park Service (1994) delineated 11 coastal "habitat types" for Katmai.

Ten permanent transects were installed in 1989 on oil-impacted beaches along the Katmai National Park coastal shoreline. Data recording from each transect included characteristics and penetration of oil, and quantitative measurements of percent cover of oil, mineral and biota. Transects were permanently marked for future relocation and monitoring (Cusick 1989).

In 1990-1995, eelgrass (*Zostera spp*.) beds impacted by the Exxon Valdez oil spill were compared with reference (non-impacted) sites to assess possible impacts from the 1989 oil spill. Based on the study, injuries to eelgrass appeared to be slight and did not persist for more than a year after the spill (Dean et al. 1998).

In 1994-97, a Katmai coastal field station was created at Kodiak and staffed by a manager/biologist and vessel operator. Several coastal surveys were conducted during this period, primarily marine debris surveys and relative abundance counts of seabirds and marine mammals (Goatcher 1994). To understand the process of post-spill recovery of Harlequin Ducks, Goatcher et al (1999) marked birds along the Katmai Coastline in 1996-97 to determine whether aggregations of individuals within local areas of the marine environment are discrete and demographically independent from populations in Prince William Sound. The Kodiak field station was closed in 1997 and manager/biologist position has remained vacant.

The largest biological dataset for the Katmai Coastline has been generated in association with brown bear studies during the 1990's. This data set includes salt marsh vegetation composition, brown bear-habitat associations, bear-forage parameters, bear movement patterns, and bear-human interactions (Smith 1996; Smith Unpubl.).

***Human Activities With the Potential to Affect Coastal Resources* -**
Katmai's marine coastline is at constant risk from environmental threats associated with petroleum development, storage, and/or transportation. The Valdez terminal in Prince William Sound receives approximately 24 billion gallons of oil per year via the TransAlaska Pipeline. There are also 15 production platforms operating in Cook Inlet. The Drift River Marine Terminal is a privately owned offshore oil loading platform in Cook Inlet with an onshore storage facility. The Nikiski oil terminal and refinery is located on the Eastern Shore of Cook Inlet. These two oil-loading facilities transfer over 3.3 billion gallons of oil per year (Potts et al., 1993).

The strong currents and a high tidal range along the Alaskan coast can transport spills great distances from their source. On March 24, 1989, the tanker vessel *Exxon Valdez* grounded in Prince William Sound, rupturing cargo tanks and spilling approximately 11 million gallons of crude oil into the sea. Katmai's coast received the greatest impact of the NPS units (U.S. National Park Service, 1990). During the summers of 1989-1991, Exxon, with the cooperation of numerous state and federal resource management agencies, engaged in an unprecedented cleanup effort in an attempt to restore the oiled shoreline to an environmentally stable condition.

The water resources of Katmai are threatened by the potential exploration and development of oil and gas in Cook Inlet and Shelikof Straight under the Outer Continental Shelf program. Oil seeps and gas seeps in Katmai were reported in the early 1900's by Martin (1905) and Smith (1925), respectively. During 1979 and 1980, the U.S. Geological Survey conducted field work to assess the petroleum potential of the Shelikof Strait based on outcrops in Katmai. The results from this field work revealed promising petroleum exploration targets in the Shelikof Strait (Smith and Petering, 1981). Presently, both the state and federal governments are planning to sell oil and gas leases near the Katmai coast (U.S. National Park Service, 1994).

A frequently unacknowledged indirect effect of the EVOS and subsequent cleanup operation was the role it played in elevating the market potential of the Katmai Coastline for tourism. In the early 1990's, vessel operators that had previously been under contract for spill cleanup used their newly acquired familiarity with the coastal resources to launch charter operations for tourists. Consequently, public use of the Katmai coastline rapidly escalated in the years following the oil spill. This has presented a challenge for park management because the parks infrastructure and capability to patrol and protect coastal resources has not kept pace with the growth in public use.

Commercial lodges on inholdings in Kukak Bay, charter vessels, and cruise ships (floating lodges), and amphibious aircraft bring large numbers of visitors to the coastline. These operations discharge contaminants into nearshore waters, introduce airborne pollutants through combustion and incineration, harvest and remove coastal resources such as finfish and shellfish, and disturb or displace wildlife from nearshore and riparian habitats. Large cruise vessels anchor in sheltered bays and inlets and use zodiac boats to access beaches and coastal streams. Combination boat/air services target coastal salt marshes for guided bear viewing and photography. All of these activities are increasing and may already present a greater human presence than commercial fishing.

Commercial fishing has the potential to adversely affect biological resources of the Katmai Coastline. Crab, salmon seine, long-line, scallop, bottom-dragger, open-ocean trawl, and urchin diving are the principle fishing activities. Historically, some of the most flagrant examples of overfishing in Alaska have occurred in Shelikof Strait. For example, following the discovery of large spawning schools of pollock in the area in the late 1980's, catches skyrocketed. Within two years they peaked, then crashed as the stock was decimated. Estimates of pollock biomass dropped by more than an order of magnitude in this period: from 3.7 million tons in the early 1980s to 300,000 tons by 1990; meanwhile sea lion populations in the area dropped by 60% (Ferrero and Fritz 1994). Marine debris from domestic trawl operations has the potential to adversely effect birds and mammals along the entire coastline (Goatcher 1994).

Coastal resource protection is complicated by jurisdictional issues. The State of Alaska Department of Natural Resources (DNR) manages the tidelands adjacent to Katmai's coast. In 1994, the DNR received applications for the placement of mooring buoys adjacent to Katmai to accommodate commercial operators who are engaged in conducting bear viewing and fishing trips. The NPS objected to the issuance of such mooring buoy permits adjacent to the designated wilderness, especially in ecologically sensitive bays such as Amalik/Geographic Harbor, Kaflia Bay, and Kukak Bay, until such time as a joint management agreement or plan could be drafted. The State expressed interest in working with the NPS and the NPS worked jointly to assemble baseline information about resources and uses along the coast. Public input was also solicited. The DNR has identified the coastal area adjacent to Katmai as a potential "Special Use Area" to be designated in recognition of the complexities of rich coastal and upland resource, the rapidly increasing public and commercial uses of the area, and the conflicting demands for public use.

Literature Cited and Selected Bibliography -

Cahalane, Victor H. A biological survey of Katmai National Monument. Washington: Smithsonian Institution; 1959;246(Smithsonian Miscellaneous Collections; v. 138, No. 5). Notes: Publication 4376

---. Field notes of Victor H. Cahalane, Katmai National Monument, summer 1954. [1954?] .

Cahalane, Victor Harrison. A biological survey of Katmai National Monument. Luntey, Robert S., Editor. Interim report on Katmai Project, Katmai National Monument, Alaska. Washington, D. C.: U.S. National Park Service; 1954; pp. 75-109. 138.

Ferrero R.C. and L.W. Fritz. 1994. "Comparisons of Walleye Pollock Harvest to Steller Sea Lion Abundance in the Bering Sea and Gulf of Alaska," NOAA Technical Memorandum NMFS-AFSC-43, Sept.1994:

Goatcher, B. 1994. Seabirds, Katmai Coast. Unpubl. Katmai National Park and Preserve, King Salmon, AK 8 pgs.

----. 1994. Draft Coastal Natural Resources Monitoring and Management Report, 1994: A summary of current year field results, status and trends. Unpubl. Rep. U. S. Natl. Park Serv., King Salmon, Alas. 18pp.

Goatcher, B., Zwiefelhofer, D. and K. Scribner. 1999. Differentiation and Interchange of Harlequin Duck Populations Within the North Pacific. Exxon Valdez Oil Spill Trustee Council Restoration Project No. 97161, Final Report

Griggs, Robert F. The beginnings of revegetation in Katmai Valley. The Ohio Journal of Science. 1919; 19:318-342. ISSN: 0030-0950.

---. Scientific results of the Katmai expeditions of the National Geographic Society I-X. [Columbus] : The Ohio State University; 1920; p. [244]. (The Ohio State University bulletin : Contributions in geographical exploration, no. 1; v. vol. xxiv, no. 15.).

Griggs, Robert F. The vegetation of the Katmai District. Ecology. 1936; 17:380-417. ISSN: 0012-9658.

Hegg, Karl M. 1967. A photo identification guide for the land and forest types of interior Alaska. Juneau, AK: Northern Forest Experiment Station, USDA, Forest Service; p. 55. (U.S. Forest Service Research Paper; v. NOR-3 1967).

Herendeen, H. 1989. Unpubl. Marine mammal population status after the 1989 Exxon Valdez Oil Spill, 37 pgs.

Kellogg, Charles E. and Nygard, Iver J. 1951. Exploratory study of the principal soil groups of Alaska. Washington, DC: Agricultural Research Administration, United States Department of Agrcuture; 138 pp., plus map(Agriculture Monograph; v. 7).

Manski, David. 1986. Spruce beetles in Katmai National Park & Preserve : A surveyof baseline conditions. Anchorage, AK: National Park Service, Alaska Regional Office;19.

Martin, C. 1989. Unpubl. Inventory of coastal seabirds in Katmai National Park and Preserve in 1989. Exxon Valdez Oil Spill Trustee Council, Anchorage, AK 39 pgs.

McNab, H. W. and Avers, P. E. 1994. Ecological Subregions of the United States: Section Descriptions . Washington, DC: Department of Agriculture, Forest Service;(Publication ; v. WO-WSA-5.).

NPFMC. 1995. North Pacific Fisheries Management Council. "Stock Assessment Report for Groundfish Resources of the Gulf of Alaska,"

Pots, R. 1993. Unpubl. Coastal seabird data sheets. Katmai National Park and Preserve, King Salmon, AK

Rieger, Samuel; Schoephorster, Dale B., and Furbush, Clarence E. 1979. Exploratory soil survey of Alaska. n.p.: Soil Conservation Service, United States Department of Agriculture; 213 pp, plus maps.

Selkregg, L. L. 1975. Alaska regional profiles, Bristol Bay Region. Anchorage, AK: The University of Alaska, Arctic Environmental Information and Data Center;313 pp.

Sellers, R.A. and S.D. Miller, 1994. Population dynamics and habitat partitioning of a naturally regulate brown bear population on the coast of Katmai National Park. Ann. Prog. Rept., Alaska Dept of Fish and Game 35 pgs.

Shephard, Michael. 2000. Ecological Subsections of Katmai National Park and Preserve, Alaska. Anchorage, AK: National Park Service, Alaska Support Office

Smith, T.S. 1996. Unpubl. Brown bear-habitat relationships at Amalik Bay, Katmai National Park, Alaska 23 pgs.

Suchanek, T.H. 1994. Intertidal communities of Katmai National Park and Preserve. Internal report on file at Katmai National Park and Preserve. King Salmon, AK

Thompson, Will Francis Jr. and Bogoraz, V. G. editor. 1954. Katmai geographic studies//Interim report on Katmai Project . . . Alaska. pp. 26-49.

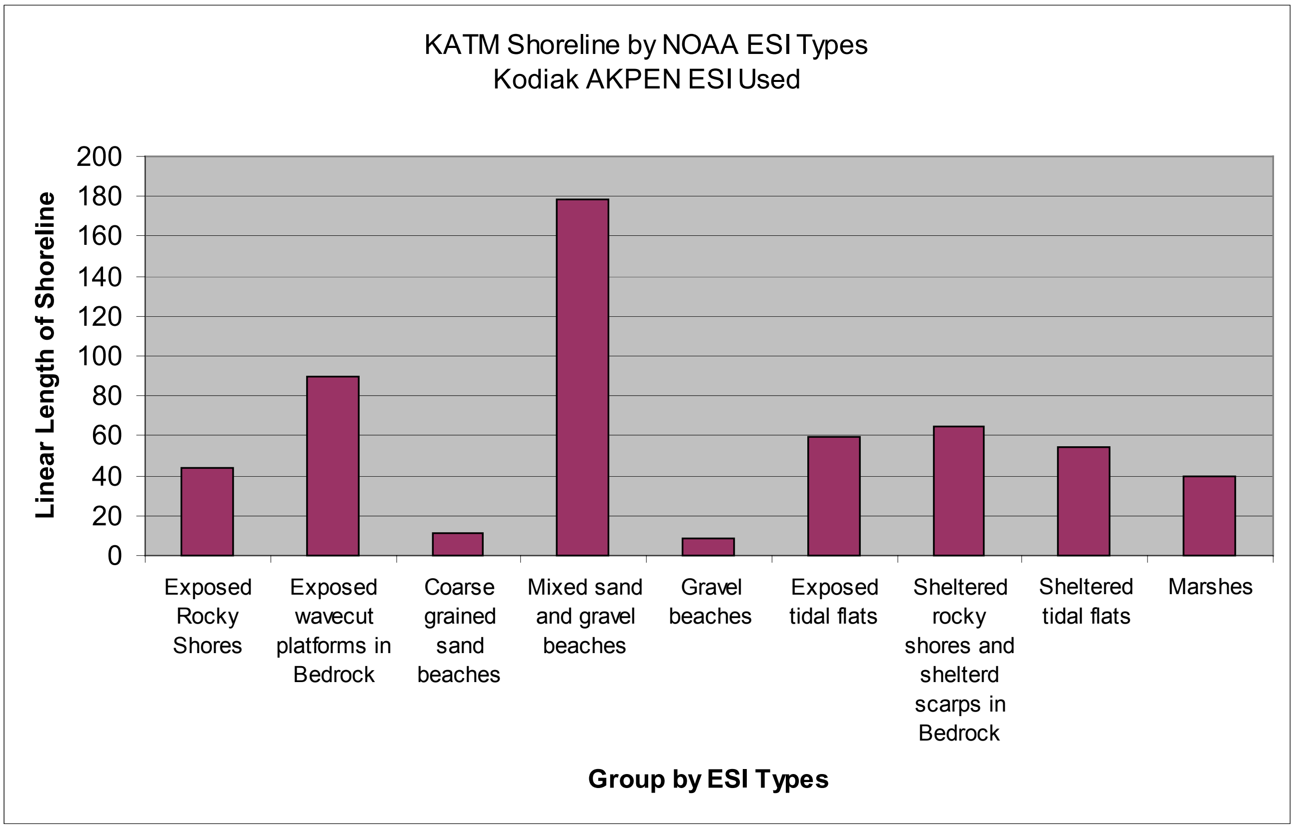
U. S. Department of the Army. 1961, Terrain study of Alaska Office of the Chief of Engineers, cartographer. Washington, DC: Army Map Service; (Engineer Intelligence Study; EIS (301)). ARLIS: GB645 T47 .

U.S. National Park Service. 1971. Wilderness study. Katmai National Monument. [Washington, D.C.] : U.S. National Park Service; 19 pgs.

Weeks, D.P. 1999. Katmai National Park and Preserve Alaska, Water Resources Scoping Report. Tech. Rept. NPS/NRWRD/NRTR-99/226. 44 pgs.

Young, Steven B. and Batten, Alan R. 1982. Proposed ecological natural landmarks in the Pacific Mountain System, Alaska. Wolcott, VT: The Center for Northern Studies;;382 pp.(Contributions from the Center for Northern Studies; v. 22).

Young, Steven B. and Racine, Charles H. 1978. Ecosystems of the proposed Katmai western extension, Bristol Bay lowlands, Alaska : final report. Wolcott, VT: Center for Northern Studies prepared for the National Park Service; p. 94 pp. (Contributions from the Center for Northern Studies; v. No. 15).


KATM Shoreline by NOAA ESI Types
Kodiak AKPEN ESI Used
Linear Length of Shoreline
200
180
160
140
120
100
80
60
40
20
0
Exposed Rocky Shores
Exposed wavecut platforms in Bedrock
Coarse grained sand beaches
Mixed sand and gravel beaches
Gravel beaches
Exposed tidal flats
Sheltered rocky shores and shelterd scarps in Bedrock
Sheltered tidal flats
Marshes
Group by ESI Types

Ecological Profile (Draft)
Lake Clark National Park-Cook Inlet Coastline

Physical Environment - The Lake Clark National Park (LACL) contains 130 miles of coastline in western lower Cook Inlet, a large tidal estuary with a length of 280 km and a width ranging from about 20 to 90 km. It is bordered on the west and northwest by the Alaska Range, on the northeast by the Talkeetna Mountains, and on the southeast by the Kenai-Chugach Mountains. Cook Inlet is an extremely dynamic, high-energy estuarine environment. The tides in the inlet are characterized by two highs and lows of unequal height in each period of approximately 25 hours (Dames and Moore, 1978). The normal tidal cycle, completed in just over 12 hours, has an average height ranging from about 5.5 m in Kachemak Bay to 8.8 m at Anchorage. Extreme high tides can be in excess of I 1 m, making the tidal ranges in Cook Inlet among the largest in the world (Britch 1976; Brower et al 1988).

The mean surface water temperature ranges from a high of 11.7 degrees (C) in July to 0.7 degrees (C) in January. The local weather is strongly influenced by the adjacent Chigmit Mountains and Aleutian Range. Dominant winds through Shelikof Strait and Cook Inlet are generally aligned with the trend of the shoreline (SW to NE) and no one direction prevails. Gales in this region generally last from 1-3 days without intermission (NOS, 1987). Seas and winds are generally much higher and stronger on the western side of the inlet particularly in the vicinity of the numerous capes and headlands (NOS, 1987).

The major sources of freshwater and sediment (from glacial erosion) to Western Lower Cook Inlet are the Drift River and Tuxedni River (Sharma 1979). Rainfall is another source of freshwater to the Inlet and several volcanoes contribute ash to the estuary. Freshwater flow into Cook Inlet varies seasonally. It is low in the winter and reaches a peak in July and August. Local areas of depressed salinity occur off the mouth of large glacially fed streams, such as the Tuxedni River (Freethey and Scully 1980).

The rivers emptying into Cook Inlet carry very high loads of suspended sediments, mainly fine glacial flour. The high tidal currents and turbulent mixing of the waters of the inlet prevent most of these suspended sediments from settling to the bottom. As a result, concentrations of suspended sediments in the waters of upper Cook Inlet are very high. Average concentrations of suspended sediments are about 200 mg/l with maximum concentrations in excess of 2,000 mg/l (Shanna and Burrell 1970, Feely and Massoth 1982). Fine-gained sediments are carried south through the lower Inlet and into Shelikof Straight and the outer continental shelf of the Gulf of Alaska. Schoch (1996) suggests that sediment transport direction along the LACL shoreline is south with counterclockwise transport in Tuxedni and Chinitna Bays.

Winter ice formation can be extensive in Tuxedni Bay and Channel. Estuary ice that forms in Tuxedni Bay is comprised of freshwater and is much harder than sea ice. Due to a combination of ice structure, lower air temperatures, and shelter from wind, this bay can remain ice covered for 3-4 months during winter (Bennett, pers obs). When the bay ice breaks up in late winter, ice flows that are moved by tides and winds gouge shorelines, cause shoreline erosion, and exert significant forces on offshore structures (B. Woods, pers comm).

Fourty-three percent of the LACL coastline is either very protected or protected from high energy waves (Schoch 1996). Over half of this length includes the salt marshes of Tuxedni and Chinitna Bays. No portions of the LACL shoreline are fully exposed to the wave climate of the Gulf of Alaska, however, southeast storm swells from the Gulf penetrate into Lower Cook Inlet during the winter months. These events cause very large berms to develop on boulder beaches in the semi-exposed regions.

Salt marsh accounts for 22% of the total shoreline length and 42% of the total intidal area. The combined soft substrates (saltmarsh, sand and mud flats) account for 90% of the total length and 98% of the total area (Schoch 1996). Combinations of rocky shores (ramps, platforms, cliffs) are a very small percentage of the total habitat type on the LACL coastline. Major freshwater streams are the Tuxedni River, Crescent River, West Glacier Creek, Red River, Johnson River, Silver Salmon Creek, and Shelter Creek. Several miles of the lower portions of the Tuxedni River, Johnson River and West Glacier Creek are tidally influenced.

Biological Resources- Cook Inlet is an extremely harsh and variable estuarine environment. Because of high suspended-sediment loads, and physical disturbances to the intertidal and seafloor due to current scour, subtidal benthic communities in western Cook Inlet may be absent or present at very low densities and diversities. Despite these adversities, a large variety of marine and estuarine plants and animals occupy the Lake Clark Coastline. The rocky intertidal zone is dominated by a Fucus (algae)/Mytilus (mussel)/bamacle assemblage (Schoch 1996). Intertidal sand flats in some locations support dense populations of mollusc bivalves, including razor, littleneck, and soft-shell clams. Intertidal salt marshes and shallow subtidal eelgrass and kelp beds are extensive in portions of Chinitna and Tuxedni Bays.

Intertidal mud flats in Chinitna and Tuxedni Bays support large to moderate standing crops of suspension and deposit feeding invertebrates (Lees 1977). Eighteen species of Polychaeta, 7 species of Mollusca and 12 species of Crustacea have been identified in Chinitna Bay (Bennett 1996). Infauna in both bays are dominated by the pink clam (*Macoma balthica*). The trophic relationship between shorebirds, sea ducks, diving ducks and *Macoma* may be the most significant near coastal predator-prey linkage along the Lake Clark National Park-Cook Inlet Coastline (Bennett 1996).

Seven seabird colonies occur along the Lake Clark coastline, the largest is in Tuxedni Channel and supports 2,500-3,000 black-legged kittiwakes (*Rissa tridactyla*) (Bennett 1996). Offshore colonies exist on Chisik/ Duck Islands in Tuxedni Bay; and Gull Island in Chinitna Bay. Chisik/Duck Islands (Alaska Maritime NWR) support the largest seabird colony in Cook Inlet. These islands have recently supported 20,000 Black-legged kittiwakes 3,000-4000 common murres (*Uria aalge*), and 6,000 horned puffins (*Fratercula corniculata*) (Slater et al 1995).

Bald eagle *(Haliaeetus leucocephalus)* nests have been surveyed along the LACL coastline since 1987 and are one of the longest continuous long-term (>10 years) data sets for biological resources. In recent years, 21-58 occupied and active bald eagle nests have existed. Post-breeding concentrations of up to 260 bald eagles occur along several rivers in early winter (Bennett 1996). Breeding peregrine falcons (*Falco peregrinus pealei*) have been documented at 6 sites along the LACL coastline, most within the Tuxedni Bay area.

During spring migration, 86,000 to 122,000 shorebirds, primarily western sandpipers (*Calidris mauri*) and dunlin (*C. alpina*), use intertidal mud flats in Tuxedni and Chinitna Bays. The Alaska Shorebird Working Group has identified Cook Inlet as critical for supporting hemispherically significant populations of Whimbrel (*Numenius phaeopus* rufiventris), Hudsonian godwit (*Limosa haemastica*), Rock sandpiper (*Calidris p. ptilocnemis*) and Western sandpiper. Rock sandpipers, designated as a "Species of High Concern", winter in Tuxedni Bay, which also offers an important stopover site for large numbers of Western sandpipers during migration. Tuxedni Bay qualifies as an International Reserve in the Western Hemisphere Shorebird Reserve Network (Andres & Gill 2000). Sea ducks, primarily surf scoters (*Melanitta perspicillata*) and white-winged scoters (*M. fusca*), are the most common nearshore waterbirds and reach peak numbers (18,500) during August (Bennett 1996).

Small pelagic schooling fish including capelin (*Mallotus villosus*), sand lance (*Ammodytes hexapterns*), eulachon (*Thaleichthys pacificus*) and Pacific herring (*Clupea harengus*) occur in nearshore and estuarne waters (Bennett, pers obs). Dominant species during summer in Tuxedni Bay juvenile pollock (*Theragra chalcogramma*), sand lance, osmerids, and herring. (Piatt et al. 1999). No information exists on seasonal abundance or distribution.

Harbor seals *(Phoca vitulina)* (200-250 animals) haul out at 3 sites (Tuxedni Bay, Chinitna Bay and Johnson River) and pup near the mouth of the Tuxedni River (Bennett 1996). Beluga whales (*Delphinapterus leucas*) seasonally occur off the mouths of glacial rivers in both bays and are most numerous (160-200 animals) during August and September (Bennett 1996, Speckman and Piatt 2000). Brown bears (*Ursus arctos*) use coastal salt marshes for foraging and mating. During an aerial survey in July 1995, 87 brown bears were sighted along the LACL coastline, primarily in Tuxedni and Chinitna Bays (Bennett 1996).

NPS Natural Resource Inventories and Monitoring- Reconnaissance-level aerial surveys of biological resources were conducted after the Exxon Valdez oil spill in 1989. These aerial surveys identified waterbird concentration areas and harbor seal haulouts (LACL files, unpubl).

In 1991-92, the Coastal Programs Division of the Alaska Support Office acquired black and white aerial photography at 1:24,000 scale (enlarged to 1:12,000) for the entire coastline of Lake Clark National and Preserve. In August 1992, NPS used this photography to classify upper, middle, and lower intertidal habitats of the entire 130 miles shoreline of the park. In addition to geomorphological classification, field surveys were conducted in August 1992 to measure beach profiles and inventory intertidal flora and infauna at selected transects.

During 1994-96, Park staff conducted a coastal resource inventory to obtain baseline data on coastal geomorphology, intertidal habitats, and distributions and abundance's of marine and near-coastal vertebrates and invertebrates. Intertidal shoreline habitats were classified at a minimum spatial scale of 10 m horizontally. The shoreline was partitioned into 338 upper, 246 middle, and 207 lower intertidal polygons with homogeneous morphodynamic attributes such as wave runup, substrate character, slope angle, and aspect (Schoch 1996). The attributes of each polygon were described and quantified allowing for statistical calculations for parametric or spatial distribution modeling of nearshore habitats.

Salt marshes (32 km^2) were delineated and mapped at a scale of 1:12,000 (Tande 1996). Five attributes were interpreted for each of 1,286 map polygons: Physiographic Location - 4 classes; Site Moisture - 2 classes; Vegetation Type -27 classes; Growth Form - 8 classes; and Landscape Feature - 13 classes. These attributes may be treated as independent variables or in combination for analysis of salt marsh vegetation communities.

Coastal resource data and metadata was compiled into a digital database and geographical information system (GIS) on CD-ROM. Data layers developed and projected for Lake Clark National Park-Cook Inlet Coastline GIS include: land status, bathymetry, topography, surface hydrology, nearshore rocks, intertidal shoreline segments, geomorphology, salt marsh vegetation, beach profile transects, invertebrate sample sites, waterbird density, raptor nests, seabird colonies, and harbor seal haulouts.

In 1996, baseline contaminant levels were established for *Macoma balthica* in Chinitna and Tuxedni Bays (Cook Inlet RCAC 1996). Contaminant analysis included polycyclinc aromatic hydrocarbons, alkyulated homologues, trace metal analysis, and bivalve condition index.

In 2001-2002, seasonal use by bears at the Glacier Spit salt marsh has been monitored at Chinitna Bay. Data collected includes semi-hourly scans of cohort type, location, and activity. Human use of the area is also being monitored. Similar data were collected at Tuxedni Bay from mid-June through July in 2001.

***Human Activities With the Potential to Affect Coastal Resources* -** There are 15 offshore oil and gas production platforms in Cook Inlet. Operations at three of the platforms have been temporarily suspended due to market conditions and low production volumes. All oil from Cook Inlet is refined at a Nikiski refinery producing gasoline, propane, butane, jet fuel, heating fuel and asphalt for Alaska markets. A chemical plant in Nikiski uses Cook Inlet natural gas as a feedstock to manufacture more than 5,000 tons of fertilizer per day. The plant is the largest fertilizer complex on the West Coast and is a major supplier to the agriculture industry in the Western United States. A gas liquefaction plant at Nikiski, the only one of its type in North America, supplies 1.3 million barrels of liquefied natural gas to Japan each month.

Pipelines connect the offshore platforms to shoreline treatment facilities and oil terminals and there are two pipelines from Nikiski to Anchorage (one for natural gas and one for product). There is a major oil tanker route that enters lower Cook Inlet at Kennedy Entrance and extends up along the eastern side of the sound to Nikiski.
Drift River Terminal, a component of Cook Inlet Pipeline Company, is 25 miles north of the LACL coastline and was built in 1966. It receives crude oil from the Trading Bay Production Facility via one 20" pipeline and ballast water from tankers. The terminal facility performs oil/water separation on the ballast water using six successive holding ponds. The cleansed water is discharged into Cook Inlet and the recovered crude oil, along with crude oil from the Trading Bay facility, is piped to a loading facility where it is transferred to tankers and barges. Storage capacity of the Drift River Terminal is 1,890,000 bbl crude oil in seven storage tanks, 8,500 bbl diesel fuel in two storage tanks, and 21,924 bbl crude fuel oil in two storage tanks.

Private inholdings in Chinitna Bay, and along the outer coast at Silver Salmon Creek support commercial lodges. These lodges primarily specialize in guided bear viewing, coastal skiff tours, and fishing. Air taxi charter and boats operators from Kenai, Soldotna and Homer also bring clients to the coastline. Other inholdings support private residences and set net fishing cabins.

A 62 square mile inholding on the north side of Tuxedni Bay is held by several Cook Inlet Native village corporations. Timber rights to approximately 42,000 acres of the lower Crescent River watershed were sold to a logging company in 1997. The timber company built a primary access road, airstrip and log transfer facility, including a 550-foot causeway extending into Tuxedni Bay, in 1998-1999. Secondary roads were built to harvest timber on the west side of the river; about 700 acres were harvested during 2000-2001. In 2002 the company applied for a state permit to construct a bridge across the Crescent River to gain access to large tracts of harvestable timber farther up the watershed. Expectations are that 10 million board feet can be harvested.

A second native corporation (CIRI) owns an inholding at the head of the Johnson River Valley. Since the establishment of the Park in 1980, CIRI has been investigating possible joint ventures to develop a copper, zinc and gold mine at this site. Exploratory work, camp infrastructure, and an airstrip have been completed near the Johnson River headwaters. In 1993, CIRI requested entitlement to road corridor and port site easements granted by law. CIRI and Westmin Resources prepared an Environmental Analysis Document to identify transportation and port easement alternatives. CIRI selected a preferred route 16 miles along the Johnson River and down Bear Creek to a port site in Tuxedni Channel. Full development was projected by 1996, however, economic uncertainties have delayed the project. The timeframe for mine development continues to be uncertain.

Literature Cited and Selected Bibliography-

Agler, B.A., S.J. Kendall, P.E. Seiser, and D.B. Irons. 1994. Population estimates of marine bird and sea otter populations in Lower Cook Inlet, Ak during June 1993. USFWS- Migratory Bird Manage., Anchorage, AK 72 pgs.

Andres, B.A. and R.E. Gill. 2000. U.S. Shorebird Conservation Plan: A conservation plan for Alaska shorebirds, Version 1.0. Alaska Shorebird Working Group, Anchorage Alaska, March, 2000. 30 pp.

Arneson, P.D. 1980. Identification and delineation of coastal migratory bird habitat in Alaska, AK Dept. of Fish and Game, Juneau. 350 pp.

Bennett, A.J. 1996. Physical and biological resource inventory of the Lake Clark National Park-Cook Inlet Coastline. Lake Clark National Park and Preserve, Kenai, AK. 137 pgs.

Britch, E.L. 1976. Tidal currents in Knik Arm Cook Inlet, Alaska. M.S. Thesis, univ of Alaska, Institute of Water Resour., Fairbanks, AK 143 pgs.

Brooks, K.M., 1985. Determination of Geographic Information System Database Charactersitics: An Application of the Information Integration Theory. Ph.D. dissertation, Oregon State University. 228 p.

Brower, W.A., H.W. Searby, J.L. Wise, H.F. Diaz, and A.S. Prechtel. 1977. Climatic atlas of the outer continental shelf waters and coastal regions of Alaska. Vol 1 Gulf of Alaska. Arctic Environmental Information and Data Center, University of Alaska, Anchorage, AK.

Calkins, D.G. 1979. Marine mammals of lower Cook Inlet and the potential for impact from outer continental shelf oil and gas exploration, development and transport. Alaska Dept. of Fish & Game, Juneau, Ak 89 pgs.

Cook Inlet RCAC. 1996. Lake Clark National Park Bivalve Study – Data Report. Kinnetic Laboratories, Inc. 7pgs.

Conant, B. and D.J. Groves. 1994. Productivity surveys of geese, swans, and brant. Migratory Bird Management, USFWS Unpubl. Rept., Juneau, AK 11 pgs.

Dames and Moore. 1978. Drilling fluid dispersion and biological effects study for the Lower Cook Inlet C.O.S.T. well. Report to Atlantic Richfield Co., Anchorage, AK 309 pgs.

_______. 1980. Ecological studies of intertidal and shallow subtidal habitats in Lower Cook Inlet, Alaska. NOAA Job No. 6797-012-20, 406 pgs.

EVOS Exxon Valdez Oil Spill Trustee Council, 1994. Final Environmental Impact Statment for the Exxon Valdez Oil Spill Restoration Plan, Anchorage, Ak

EVOS Exxon Valdez Oil Spill Trustee Council, 1992. Restoration Framework, Vol I. Anchorage, Ak 52 pgs.

Feely, R.A. and G.J. Massoth. 1982. Sources, composition, and transport of suspended particulate matter in lower Cook Inlet and northwestern Shelikof Strait, Alaska. NOAA Technical Report ERL 415 - PMEL 34.

Franqois and Giichter. 1992. Alaska Update: February 1990-April 1992. Outer Continental Shelf Oil & Gas Activities. OCS Infonnation Report MMS 92-0053. U.S. Dept. of the Interior, Minerals Management Service, Hemdon, VA.

Freethey, G., and Scully, D. 1980. Water Resources of the Cook Inlet Basin, Alaska. USGS, Hydrologic Investigations Atlas, HA-620, 1980

Hamilton, C.I., S.J. Starr and L.L. Trasky. 1980. Recommendations for minimizing impacts of hydrocarbon development on fish and wildlife of Lower Cook Inlet. (unpubl.) Ak Dept. of Fish and Game, Anch, AK.

Hansen, D.J. 1985. The potential effects of oil spills and other chemical pollutants on marine mammals occurring in Alaskan waters. USDI-Minerals Manage Serv. OCS Report MMS 85-0031. Anchorage, Ak 21 pgs.

Hatch, S.A., G.W. Kaiser, and G.V. Bird. 1993. A seabird monitoring program for the North Pacific. Trans. 54th North American Wildlife and Natural Resources Conf. Wildl. Manage. Inst.

Hatch, S.A., G.V. Byrd, D.B. Irons, and G.L. Hunt, In Press. Status and ecology of kittiwakes in the North Pacific. In: Status and Conservation of Temperate North Pacific Seabirds. Vermeer, K. et. al., eds. Can Wildl Serv Pub. Ottawa, Canada.

Haugh, J.R., and J. P. Potter. 1975. Evaluation of raptor populations: Tuxedni Bay, Illiamna Lake, Noatak River Valley, and Forty Mile River Valley of Alaska. U.S.D.I., Bur. of Land Manage. and U.S. Fish and Wildl. Serv. 55pp.

Hazard, K. 1988. Beluga whale, pp 195-236 In Lentfer, J.W. Ed. Selected marine mammals of Alaska. Species accounts with research and management recommendations. Marine Mammal Commission, Washington, D.C.

Hood, D.W. and S.T. Zimmerman. 1986. The Gulf of Alaska-Physical environnment and biological resources. USDI-MMS publication no. 86-0095, Washington, D.C. 655 pgs.

Hoover-Miller, A.A. 1994. Harbor seal biology and management in Alaska. Contract No. T75134749. Marine Mammal Commis., Washington, D.C. 45 pgs.

Kinney, P.J., J. Groves and D.K. Button. 1970. Cook Inlet Environmental data, R/V Acona cruise 065 - May 21-28, 1968. Inst. of Marine Sci., Univ of Alaska. Rept No. R-70-2

Kyle, R.E., and Brabets, T.P., 2001, Water Temperature of Streams in the Cook Inlet Basin, Alaska, and Implications of Climate Change: U.S. Geological Survey Water-Resources Investigations Report 01-4109, 24 p.

Lees, D.C. 1977. Reconnaissance of the intertidal biota and shallow subtidal biota Lower Cook Inlet. Dames & Moore Rept 6797-004-20506 pgs.

Michel, J., M.O. Hayes and P.J. Brown. 1978. Application of an oil spill vulnerability index to the shoreline of lower Cook Inlet. Environmental Geology 2(2):107-117

Minerals Management Service (MMS). 1984. Gulf of Alaska/Cook Inlet Sale 88. Final Environmental Impasct Statement. Vol 1. USDI-ASOCSR, Anchorage, AK 470 pgs.

Nelson, D.C. Unpublished. A review of Alaska's Kenai Peninsula east side beach recreational razor clam fishery, 1965-1980. Alaska Department of Fish and Game, Division of Sport Fish, Soldotna, Alaska.

NMFS. 1992 Status report on Cook Inlet Belugas. National Marine Fisheries Service report No. 43, Anchorage, AK 22 pgs

O'Clair, C.E. and S.T. Zimmerman. 1986. Biogeography and ecology of intertidal and shallow subtidal communities. Pages 305-344, In D.W. Hood and S.T. Zimmerman (Eds.), The Gulf of Alaska: Physical Environment and Biological Resources. National Oceanic and Atmospheric Administration and NEnerals Management Service, Anchorage, AK. MMS 86-0095.

Piatt, John F., Gary Drew, Thomas Van Pelt, Alisa Abookire, April Nielsen, Mike Shultz, and Alexander Kitaysky. 1999. Biological Effects of the 1997/98 ENSO in Cook Inlet, Alaska.

Pitcher, K.W. and D.G. Calkins. 1979. Biology of the harbor seal in the Gulf of Alaska. Ak Dept. of Fish and Game Final Rept. 229, Anch., Ak. 72 pp.

Reed, R.K. and J.D. Schumaker. 1986. Physical oceanography: In Hood, D.W., S.T. Zimmerman eds., The Gulf of Alaska, Physical Environment and Biological Resources: NOAA and MMS publication, U.S. Government Printing Office, Washington, D.C. pp. 57-76.

Sanger, G.A., R.D. Jones, and D.W. Wiswar. 1979. The winter feeding habitats of selected species of marine birds in Kachemak Bay, Alaska. Unpubl. Ann Rept. USFWS, Anchorage. 35 pgs.

Schoch, G.C. 1996. The classification of nearshore habitats: a spatial distribution model. M.S. Thesis. Coll. Oceanic and Atmospheric Sci., Oregon State Univ., Corvallis 146 pgs.

Sharma, G.D. 1979. The Alaska Shelf: Hydrographic, sedimentary and geochemical environment. Springer-Verlag, New York 338 pgs.

________, and Burrell. 1970. Sedimentary environment and sediments of Cook Inlet. American Assoc. of Petroleum Geologists Bull. 54:647-654

Slater, L, G.V. Byrd, J.W. Nelson, and J. Ingrum. 1995. Monitoring populations and productivity of seabirds at colonies in lower Cook Inlet, Alaska, in 1993 and 1994. OCS Study, MMS 95-0025, Anchorage, AK 48 pgs.

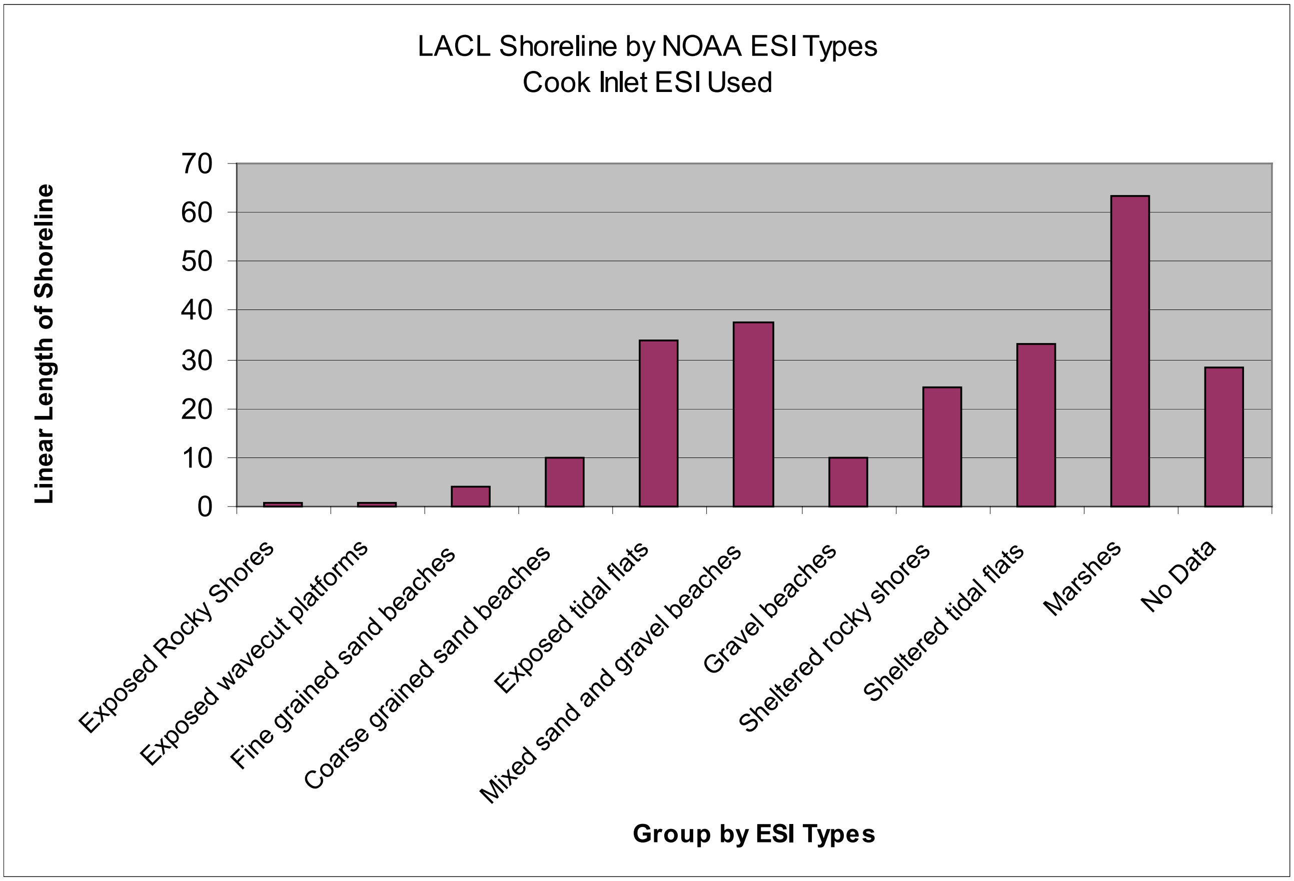
Speckman, S.G, and J.F. Piatt. 2000. Historic and current use of lower Cook Inlet, Alaska, by belugas, Delphinapterus leucas. Marine Fisheries Review 62(3):22-26

Szarzi, N.J. 1991. Distribution and abundance of the Pacific razor clam, Siliqua patula (Dixon), on the east side cook Inlet beaches. Master's thesis, University of Alaska, Fairbanks.

Tande, G.F., 1996. Mapping and Classification of Coastal Marshes, Lake Clark National Park and Preserve, Alaska: Natural Heritage Foundation, Anchorage, Alaska

Tande, G.F. and K. Boggs. 1995. Vegetation inventory and mapping. In: S.V. Cuccarese (ed.). Kodiak launch complex environmental assessment and baseline. Prep. for Alaska Aerospace Development Corporation. Environment and Natural Resources Institute, University of Alaska, Anchorage, AK. 3 Vols.

Vince S.W. & A.A. Snow. 1984. Plant zonation in an Alaskan saltmarsh. J.Ecology 72:651-667



.

Ecological Profile (Draft)
Kenai Fjords National Park-
Gulf of Alaska Coastline

Physical Environment - Kenai Fjords National Park is located on the southeastern coast of the Kenai Peninsula. The coastal zone is a narrow band of exposed headlands and deep fjords, squeezed between the Gulf of Alaska and Kenai Mountains. The outer coast of Kenai Fjords rides the exposed edge of the North American Plate where the Pacific Plate is “diving” beneath the North American plate, and is subject to earthquakes of moderate frequency and intensity, with resulting ocean floor landslides and terrestrial uplift and subsidence. A recent compilation (Haeusser and Plafker 1995) indicates a dozen earthquakes in the region of Kenai Fjords of magnitude 6.0 or greater during the past century. The beautiful circular bays of the Aialik, Harris and McCarty Peninsulas are drowned cirques of the Chugach Mountains, which were partially submerged by tectonic subsidence during the Holocene (Hamilton and Nelson 1989).

The bedrock of the Resurrection Peninsula and the Kenai Fjords coast is a mixture of faulted metamorphics and intruded volcanics. An arc of cretaceous upper Jurassic rocks stretches from Kenai Fjords near Gore Point around through the Chugach Mountains, as far east as Glacier Bay. These rocks are primarily “grawyacke, slate, argillite, minor conglomerates, volcanic detritus and interbedded mafic volcanic rocks” (Beikman 1980). Several granite and granodiorite intrusions are scattered along the coast; examples are the southern ends of the McCarthy and Harris Peninsulas. This arc of metamorphic rocks with quartz veins host gold-bearing arsenopyrite. (Richter 1970).

The epicenter of the 1964 “Great Alaska Earthquake” was 95 miles NE of the town of Seward, and 100-150 miles from the coast of Kenai Fjords. Land at Seward subsided about 3 feet, and abundant evidence at the heads of the fjords would suggest similar subsidence along the coast west of Resurrection Bay. Additional lowering of the land surface at Seward was caused by underwater landslides in the fine-grained silts and clays deposited by glacial rivers at the head of Resurrection Bay. Similar landslides (and tsunamis) may have occurred in Beauty Bay and North Arm of the McCarty Fjord at the western end of the park. However, most of the fjords have very steep bedrock walls or tidewater glaciers at their heads, and lack sediment buildups. Saltwater intrusion and tidal flooding have converted freshwater wetlands and spruce forest bands throughout the fjords to tidal marshes and “ghost forests”, indicating terrestrial subsidence. These areas are evident in Beauty Bay, North Arm, near Delight Lake and James Lagoon, all part of the Nuka Bay complex, as well as the outer beaches of Northwestern Lagoon, and many of the coves and bays of Aialik Bay, Bulldog Cove and the coast offshore of Bear Glacier and beaches throughout the islands and coasts of Resurrection Bay. In an interesting reversal, lands east of Resurrection Bay in Day Harbor and Horsehead Bay appear to have uplifted, showing characteristic new, higher beach lines and rows of young healthy Sitka spruce growing out of windrows of driftwood and marine detritus. This trend continues east into Prince William Sound, culminating in 38 ft uplift on Montague Island.

Pleistocene and Holocene glaciations are among the major forces in shaping the land and ecological processes of the Kenai Fjords coastline. Warming and cooling cycles over the past (at least) 100,000 years have resulted in multiple glacial advances and retreats. Glaciers that have covered Kenai Fjords have swept down from the Alaska and Aleutian ranges, or more recently, from the Harding Icefield capping the lower Kenai Mountains. Global cooling trends lower snowline and increase snow deposition in high terrain. Karlstrom (1964) shows ice sheets of Naptown age (7000-1100 yrs BP) completely covering much of the Alaska Range, Cook Inlet, Kodiak, Shelikof Straits, and the southeastern Kenai Peninsula. Although the locations of the terminal moraines are unknown, Karlstrom shows the ice extending 50-100 miles into the Gulf of Alaska beyond the current coastline. These glaciations completely covered the Kenai Mountains, indicating ice in excess of a mile thick. Moving ice over a mile deep exerts powerful forces on the terrain beneath it, and has carved off all soft and loose material, leaving steep polished bedrock walls and deep submarine valleys all along the Kenai coast.

More recent glaciations, although impressive in their impacts on the landscape, are mere whimpers in the scheme of glacial cycles. The latest glacial advances apparently reached their maximal extent in the 19th century, and are currently undergoing a fairly dramatic retreat. Nearly 40 outlet glaciers flow off the Harding Icefield, with seven of these terminating as tidewater glaciers in Aialik, Northwestern and McCarty fjords. Approximately 100 yrs BP, these fjords were filled with glaciers that rested on terminal moraines miles seaward from their current termini. When a glacier retreats off the support provided by its terminal moraine, the floating ice sheet breaks up and retreats rapidly. McCarty Glacier has retreated 14.5 miles, and Northwestern and its associated glaciers have retreated over 9 miles since mapping by USGS in 1909 (Rice 1987). A rock outcrop has recently appeared in the face of Northwestern Glacier, indicating that its face may soon be grounded.

The coast has a typical maritime climate, with cool rainy summers and snowy, storm driven winters. The occasional calm sunny day is a treat to be savored. Steep mountains rising straight from sea level to over 5000 feet force moisture laden storms to rise, where cooling temperatures and loss of moisture holding capacity cause the clouds to drop massive loads of snow onto the Harding Icefield. Rice (1987) cored the Harding Icefield above Exit Glacier, and measured nearly 20 ft of accumulated snow, or 11.3 ft of water for snowyear 1984-85. Lower elevations are the recipients of heavy rains and misty days. Ferocious storms rake the outer coasts, especially the headland cliffs and outer fjords exposed to prevailing southeast storms. North Pacific and Gulf of Alaska lows curl counterclockwise right into the Kenai Fjords coast. Rainfall is heaviest in Aialik Bay ranging from 45-80" during summer months of the 1990 decade, decreasing somewhat along the coast to the west. Nuka Bay records show 40-50% rainfall for the same summer months (NPS 1999). Aialik Bay frequently gets 3-4" of rainfall in one day, and August 20, 1993 recorded a memorable 10.55".

Freshwater streams on the Kenai Fjords coast tend to be short and very steep. Waterfalls abound, including an 800' falls above the North Arm of Nuka Bay. Recent deglaciations have opened up new streams and lakes, which are being colonized by salmon. The most recent example of this is Delectable (Delusion) Lake on the east side of McCarty Fjord, icefree within the past 40 years. Although the stream is steep, fast and very rocky, red, coho and pink salmon have ascended it to spawn in the lake (York and Milner 1999). Streams are generally “flashy”, in that the flows respond rapidly to rain events, which can be extreme along this coast. Glacial streams, formed of meltwater from grounded and hanging glaciers, also tend to be short, but lower gradient than most of the clear water streams. Sediment loads tend to be higher at the upper ends of fjords, where glacial waters are slow to mix with main Gulf waters. Primary glacial stream flow into Nuka Bay, Northwestern Lagoon and Aialik Bay. Glaciers such as Bear, Dinglestadt and Pederson have silty lakes at their faces.

Tidal ranges for the coast are moderate, in the range of -3.2 to +14 feet. Several coastal lagoons (either formed or modified by the 1964 earthquake) provide marine estuary marshes along an otherwise rocky coast. Strong storms, especially when occurring at times of high tides, often drive surges of salt water or spray inland. A strong marine current swings along the outer coast from Prince William Sound around to Shelikof Strait. This current is the migratory hiway for several species of whales, (and probably other species of marine mammals and fish). It also carries coastal detritus and incidental pollutants from east to west along the entire coast. Sea surface temperatures off the Kenai Fjords coast range from 40-55 ^{o}F throughout the year (Robinson 1957).

The Kenai Fjords coast is a series of deep narrow fjords cutting into the Kenai Mountains, spaced by even steeper rock cliffs along the exposed outer coast. Over a third of the park’s coast is impacted by high energy waves, primarily driven by offshore winds and Gulf storms. An additional quarter is low and very low energy protected coves and lagoons (Table 1). Fjord waters in front of tidewater glaciers are usually dense with icebergs and brash ice which has calved off the glacier. Tides carry these bergs down-fjord many miles, but they seldom escape the main fjords into the Gulf. It is unlikely that the fjords freeze over during winter, although the lagoons and sheltered coves may build up shore ice in areas with fresh water influx.

Table 1. Energy regimes along Kenai Fjords coast. (From Mann 1995)

Energy Regime	Mileage	Percent
very low-lagoons	69	13
Low	51	10
Moderate	226	42
High	192	36

Biological Resources - Kenai Fjords National Park has been mapped into two major ecological subsections, or ecosystems: The Fjordlands (45%), and the Harding Icefield (55%) (Tande and Michaelson 2001). Although not included in the Park Service jurisdiction, the park is ecologically linked to the offshore marine ecosystem, and the offshore islands, most of which are part of the USFWS Alaska Maritime National Wildlife Refuge.

The near shore pelagic realm supports many species of fish, including rock fish, halibut, ling cod, pollock, and char. All five species of pacific salmon migrate through offshore waters and spawn in Kenai Fjords streams. Forage fish, such as caplin and herring, and several species of shrimp abound. Commercial fishing for salmon and halibut occurs in the fjords and in lagoons such as James and McCarty in McCarty Fjord.

The Gulf current provides a migratory path for humpback, grey, Minke and fin whales in spring and fall. A few humpbacks linger and feed on krill in Resurrection Bay, Harris Bay and the West Arm of Nuka Bay (Rice 1989). A quasi-resident pod of killer whales frequents outer Resurrection Bay. Dall's porpoises are frequently sighted at the mouths of the fjords, usually riding the bow wave of vessels. Harbor seals congregate at the upper ends of Aialik, Northwestern and McCarty fjords for pupping and molting on the ice from tidewater glaciers. The largest sea lion rookeries are on exposed slanted rocks at the surf line on the Pye and Chiswell Islands. Although much of the pupping and breeding activities take place in the Maritime Refuge, sea lions use Kenai Fjords rocks as haul outs in smaller numbers. Major feeding and hang out areas for sea otters are the submerged moraines in Aialik, Northwestern and McCarty fjords, and the sheltered covers and lagoons of Nuka Bay.

The cliffs of the exposed headlands and outer islands are locations for amazing seabird rookeries. The Chiswell and Pye Islands are nesting grounds for thousands of pelagic seabirds, including tufted and horned puffins, black-legged kittiwakes, murres, pigeon gillamonts, and three species of cormorants (Miller 1984). Smaller rookeries are found throughout the fjords, especially on the outer headlands, and rocky islands inside the fjords. Marbled murrelets nest under glacial rocks and in old Sitka spruce along the coast. Their haunting calls before dawn heralds their return from a night's fishing at sea. Black oystercatchers scratch shallow nests into gravel beaches just above the tide-lines and protect them viciously from beachwalkers. Glaucous-winged gulls are aggressively colonizing recently deglaciated islands in the fjords. Bald eagles nest along the coast, averaging 50 active nests per year. And crows cruise the beaches and wind currents with raucous calls.

Vegetation communities of the coast lands reflect the harsh environment, and Holocene glacial and tectonic events. Beginning at the intertidal and moving upward: sheltered waters have stands of *Laminaria*, grading into *Fucus* in shallow mudflats exposed at low tides. An eelgrass bed grows in Pilot Bay of the North Arm of Nuka Bay. Gravel beaches grade into a supra-tidal community of beach ryegrass, beachpea and *Hockenyna* with scattered flowering forbs such as iris and jacob's ladder. Protected lagoons, like the backs of James and Beauty Bay have rich beds of goose tongue, a favorite spring food for bears. Exposed rocky cliffs have tufts of grasses and perennial forbs, some richly fertilized and aerated by puffin nests.

Alder stands and Sitka spruce forests begin immediately above the storm tide zone. Alder is a rapid invader in disturbed zones, following avalanche tracks from the alpine down to tide line. Scattered grasses and forbs find a foothold under the shrubs. Alder provides nitrogen for recently de-glaciated soils, enriching the environment for spruce invasion. Sitka spruce appear to move into de-glaciated terrain within 20 years of ice retreat (Rice and Spencer 1990). Recently developed Sitka spruce stands have uniform aged trees with a thin moss ground cover, scattered grasses and shrubs such as salmon berry and *Menziesia*. Older stands, growing through the last glacial maximum, have spruce of varying ages, thick moss ground cover and on the tree limbs, with alder, salmonberry and Devil's club in openings. A Sitka spruce cut down in Palisade Lagoon was over 700 years old and seven feet in diameter at the time of its death in 1990. It appears that there were spruce forest refugia perched in high valleys above the ice limits that are providing seed sources miles up-valley of the glacial terminus forests.

Terrestrial mammals have a scattered distribution along the coast. Many species had to survive the glacial era perched on the ice free peninsulas and valley refugia. Others, such as bears, may have traveled over the Harding Icefield more recently. Both black *(Ursus americanus)* and brown bears frequent the coast, feeding on tidal detritus, avalanche carcasses and spring greens until salmon start running each summer. Wolverines are frequently sighted back in the heads of the fjords. River otters move along the coast, denning in the forests and fishing out in the ocean and lagoons. Porcupines (*Erethizon dorsatum)* and red squirrels (*Sciurus vulgaris)* are moving up-fjord with the advancing spruce seedlings. Mountain goats *(Oreamnos Americanus)* use rocky cliffs along the coast, often sighted right at the water's edge with kids, and spending winter storms hunkered down in the highest spruce stands. Moose have made a recent appearance in Nuka Bay where retreating glaciers have opened up the valleys from Kachemak Bay.

NPS Natural Resources Inventories and Monitoring- A dendrochronological study of tree growth on glacial moraines below Exit Glacier was initiated by the NPS regional plant ecologist and documents minimum dates for occupation of the valley by Exit Glacier (Ahlstrand,1983). Transects of trails and roads in the Exit Glacier area have been established by seasonal resource management staff documenting human impacts in the vicinity of access routes.

Glacial geologists have sampled interstadial trees in the fjords to help document forest occupation of these areas prior to glacial advance in neoglacial times (Wiles, 1990). A study documenting stream colonizaton by invertebrates and salmonids was initiated in the Delight, Desire, Delusion Lakes system (Milner, 1999). Research has been initiated detailing early succession on glacial till: mycorrhizal colonization and patch formation (Helm, 1994).

Annual Bald eagle nest occupancy/productivity surveys, Black oystercatcher productivty surveys, and harbor seal population index counts are conducted by park resource staff.

Human Activities With the Potential to Affect Coastal Resources- Humans have probably lived along this coast for hundreds of years, moving in and out with the glacial movements, and the associated resources (Crowell and Mann 1998). Aboriginal sites have been identified in Northwestern Lagoon, Yalik Bay, Aialik Bay and McArthur Pass. Successive waves of resource extraction have occurred along the coast: sea otter pelts, gold mining, commercial fishing, scattered logging, iceberg "mining" for sale to Japanese bars, and seal hunting (for bounty). Currently, a major source of resource utilization is day-boat trips for tourists out of Seward.

Commercial fishing continues along the coast, mainly inside the fjords. Red salmon are seined off the mouths of Delight and Desire creeks and Pederson lagoon, and halibut are caught in the outer fjords and near-coast waters of the Gulf. A major concern with commercial fishing has been the storing of gear and fish onshore with attendant bear problems and fatalities. Recreational fishing is mainly for halibut, rock fish and silver salmon off the park coasts. Some fishers from Homer and Cooper Landing fly in for red salmon and dolly varden in Nuka Bay.

Two lode gold mining claims are "still on the books" in Nuka Bay: Beauty Bay and Surprise Bay. Although not likely to go to patent, these parcels could be the sites of mining-related activities. Other private in-holdings of the Port Graham entitlement include large coastal parcels of Nuka Bay, McCarty Fjord, Paguna Arm, Harris Bay and Aialik Bay totallying 46, 265 acres (NPS 2002). The NPS has no administrative or regulatory authority on the private lands. Currently, no development plans are known, but potential exists for lodges to support wilderness tourism, commercial fisheries, hunting or even some logging.

Currently, one of the largest on-going human activities on the coast is the proliferation of day boat trips out of Seward. In 1989, one company ran two vessels on daily tours during the summer. Now three large with approximately 15 vessels make daily trips to Resurrection, and Aialik Bays and Northwestern Lagoon. Additionally, many smaller charters run fishing trips to Resurrection and Aialik Bays. There has also been a rapid increase in kayak trips, which are taken out to Aialik or Northwestern fjords on faster boats and dropped off for multi-day trips, or are flown from Homer to Nuka Bay. Four public use cabins were build by NPS: two in Aialik, one in McCarty and one in the West Arm of Nuka Bay. These all receive extensive use, especially those in Aialik Bay. Impacts of beach campers on the near shore meadows, oystercatchers and black bears are being studied.

Other human activities and potential impacts are difficult to quantify. The 1989 Exxon Valdez oil spill and subsequent cleanup activities had severe impacts to the coast of Kenai Fjords (Spencer 1990). Oil was still on the beaches and driftwood in 1996, and we can assume that oil is buried deep in gravel beaches and quiet mucky backwaters.

Realistically, the chance of another spill of similar magnitude is a function of the trajectories of luck and declining Prudhoe production. Oil laden tankers travel offshore from the Cook Inlet oil wells. The Gulf current and the North Pacific also bring all kinds of marine debris to the outer beaches: drums, plastic of every description and commercial fishing nets and floats. The State of Alaska recently refused a permit request for an oyster farm in Three Hole Bay of Aialik Bay. However, there will probably be additional requests for such farms that won't be denied as a function of safety and the need for recreational anchorage space.

And the really big unknown: global climate change. Warmer ocean currents may bring exotic species to our shores–already a green turtle gone astray was reported in Prince William Sound. Some studies suggest that global warming is increasing snow precipitation and building the Harding Icefield. If true, in time the glacial retreat may slow or even reverse. Kenai Fjords National Park could be covered with advancing glaciers yet again, to the continued shaping of the fjord landscape and ecosystems.

Literature Cited and Selected Bibliography-

Ahlstrand, Gary. 1983. Dendrochronological Evidence of the Recent History of Exit Glacier. Progress Report, Kenai Fjords National Park, Alaska.

Beikman, H.M. (Compiler). 1980. Geologic Map of Alaska. Scale 1:2,500,000. G78301, USGS. Reston Va. 2 map sheets.

Crowell, A.L. and D.H. Mann. 1998. Archaeology and Coastal Dynamics of Kenai Fjords National Park, Alaska. DOI-NPS. Anchorage, Alaska. Report and digital files (at AGDC clearinghouse http://agdc.usgs.gov) 232 pgs.

Hamilton, T.D. and S. W. Nelson. 1989. Introduction to Guide to the Geology of the Resurrection Bay-Eastern Kenai Fjords Area. Alaska Geological Society, Anchorage, Alaska. Pgs 1-4.

Haeusser, P.J. and G. Plafker.. 1995. Earthquakes in Alaska. (http://quake.wr.usgs.gov/prepare/alaska/). USGS Open file report 95-624. 1 map

Helm, D. 1994. Vegetation Succession Near Exit Glacier, Kenai Fjords National Park, Alaska. University of Alaska Fairbanks, Agricultural and Forestry Experiment Station, Palmer, Alaska.

Karlstrom, T.N.V. 1964. Quaternary Geology of the Kenai Lowland and Glacial History of the Cook Inlet Region, Alaska. USGS. Wash D.C. 1964. 69 pgs, 7 plates.

Martin, I. 2002. Review comments on draft KEFJ Ecological Profile. Pers comm.

Miller, D.W. 1984. A Guide to Alaska's Kenai Fjords. Wilderness Images. Seward, Ak. 94 pgs.

Milner, A, and York, G. 1999. Colonization and Community Development of Salmonids and Benthic Macroinvertebrates in a New Stream Within Kenai Fjords National Park, Alaska.

Nelson, W.S., M.L. Miller and J.A. Dumoulin. 1989. The Resurrection Peninsula Ophiolite. *In* Guide to the Geology of the Resurrection Bay-Eastern Kenai Fjords Area. Alaska Geological Society, Anchorage, Alaska. Pgs 9-18.

NPS. 1999. Weather Observation Data Set 1990-1998, Aialik and Nuka Bays, Kenai Fjords National Park. Digital files.

NPS 2002. Land record files. AKSO Lands files–maps, summaries and digital files.

Rice, W.D. 1987. Changes in the Harding Icefield, Kenai Peninsula. Alaska. MS Prof Paper, Univ of Alaska. 120 pgs.

Rice, W.D. 1989. Sensitive Wildlife Habitat. NPS files. 1:250,000. 1 map.

Rice, W.D. and P. Spencer. 1990. Tree cores of sitka spruce along the temporal sequence of Northwestern Glacier. Unpublished data collected in 1990.

Richter, D.H. 1970. Geology and Lode-Gold Deposits of the Nuka Bay Area, Kenai Peninsula, Alaska. USGS Prof Paper 625-B. USGS, Wash D.C.16 pgs, 1 map.

Robinson, M.K. 1957. Sea Temperature in the Gulf of Alaska and in the Northeast Pacific Ocean, 1941-1952. Scripps Inst of Oceanography, University of California Press, Berkeley, Calif. 98 pgs.

Spencer, P. 1990. White Silk & Black Tar.Bergamot Books, Minneapolis, Minn.181 pgs.

Tande, G.F. and J. Michaelson. 2001. Ecological Subsections of Kenai Fjords National Park, Alaska. The Alaska Natural Heritge Program, University of Alaska, Anchorag, Alaska. 19 pts + digital data files.

York, G. and A. Milner. 1999. Colonization and Community Deveopment of Salmonoids and Benthic Macroinvertebrates in a New Steam Within Keani Fjords National Park, Alaska. Final Report the NPS, Coop Agreement no CA 9700-2-

9021. ENRI, University of Alaska. Anchorage, Alaska. 100 pgs.

Beikman, H.M. (Compiler). 1980. Geologic Map of Alaska. Scale 1:2,500,000. G78301, USGS. Reston Va. 2 map sheets.

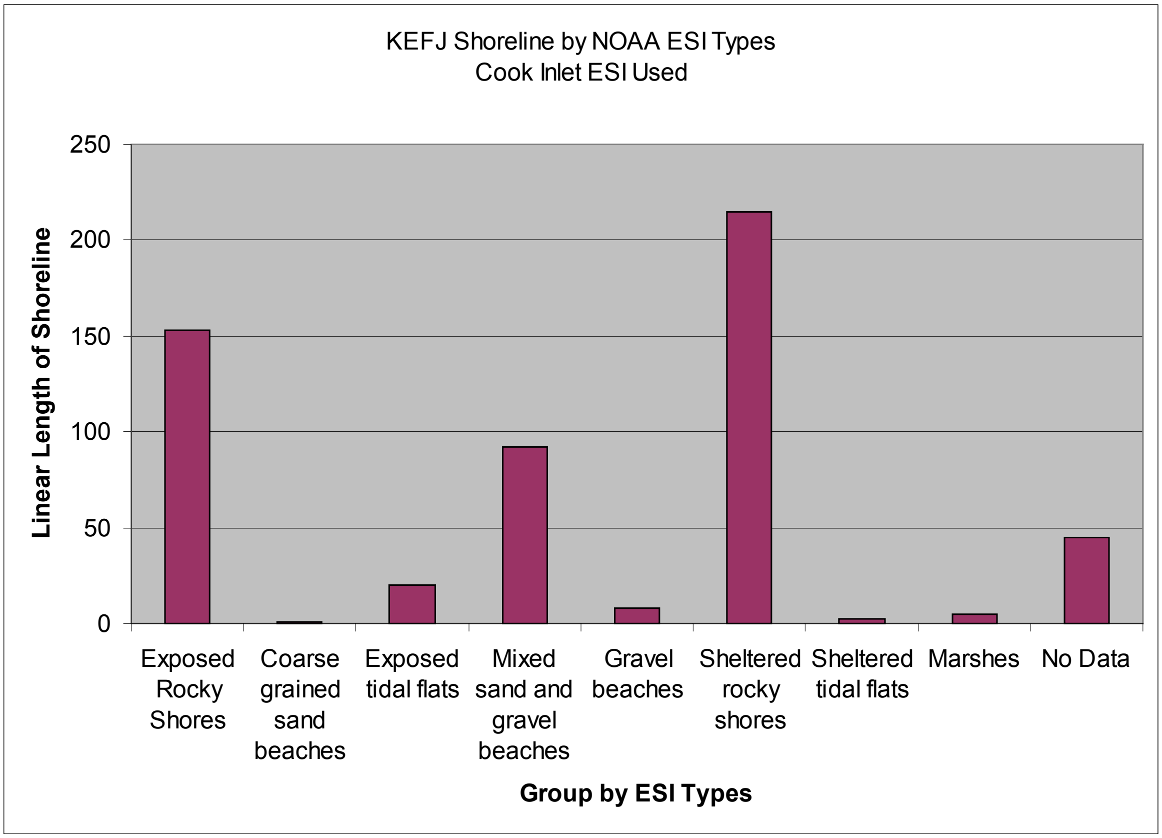
Nelson, W.S., M.L. Miller and J.A. Dumoulin. 1989. The Resurrection Peninulsa Ophiolite. *In* Guide to the Geology of the Resurrection Bay-Eastern Kenai Fjords Area. Alaska Geological Society, Anchorage, Alaska. Pgs 9-18.

Richter, D.H. 1970. Geology and Lode-Gold Deposits of the Nuka Bay Area, Kenai Peninsula, Alaska. USGS Prof Paper 625-B. USGS, Wash D.C.16 pgs, 1 map.

USGS. 1995. Earthquakes in Alaska.(http://quake.wr.usgs.gov/prepare/alaska/). USGS Open file report 95-624. 1 map

Hamilton, T.D. and S. W. Nelson. 1989. Introduction to Guide to the Geology of the Resurrection Bay-Eastern Kenai Fjords Area. Alaska Geological Society, Anchorage, Alaska. Pgs 1-4.

Karlstrom, T.N.V. 1964. Quaternary Geology of the Kenai Lowland and Glacial History of the Cook Inlet Region, Alaska. USGS. Wash D.C. 1964. 69 pgs, 7 plates.


KEFJ Shoreline by NOAA ESI Types
Cook Inlet ESI Used
Linear Length of Shoreline
250
200
150
100
50
0
Exposed Rocky Shores
Coarse grained sand beaches
Exposed tidal flats
Mixed sand and gravel beaches
Gravel beaches
Sheltered rocky shores
Sheltered tidal flats
Marshes
No Data
Group by ESI Types

Ecological Profile (Draft)
Aniakchak National Monument and Preserve - Gulf of Alaska Coastline

Physical Environment- Aniakchak National Monument and Preserve is located about a third of the way down the Alaska Peninsula. The park unit is due west of the southern end of Kodiak Island, 150 miles southwest of Katmai National Park and Preserve, and 400 miles southwest of Anchorage. The Aniakchak coastline extends 80 miles from Cape Kunmik to Kujulik Bay on the peninsula's southern mountainous spine. The coast is rugged with precipitous cliffs, offshore reefs, and islands. Three sheer-faced peninsulas jut into the ocean creating three bays that are completely or partially within the preserve. Aniakchak and Amber Bays are large, exposed bays with wide cinder-covered beaches. Kujulik Bay is more protected, narrower, and has sandy, cinder beaches. Tidal forces are generally moderate. The Aniakchak River flows into the ocean in Aniakchak Bay. Here, ancient beach lines parallel the modern beach for several hundred feet. Behind the beach lies a large lagoon. Each of the other bays have streams emptying into them.

During the Quaternary period, volcanoes in and near Aniakchak have been active, with the dominant volcanic center at Aniakchak Volcano. Ancestral Aniakchak Volcano underwent a catastrophic explosive eruption about 3400 years BP, blanketing much of the surrounding landscape with thick, fast-moving pyroclastic flows. Eruptions continued after the Aniakchak Caldera was formed. Concurrent with the volcanic activity was a series of glacial advances that carved the landscape and deposited thick sequences of till and other glacial debris. During times of glacial maximums, ice sheets extended from the Aleutian Range well into coastal waters. Changes in sea level during this period produced near-shore marine deposits in the lowlands.

Aniakchak's climate is cool, windy, and wet. Storms, brought by Pacific Ocean winds, frequently visit the area. Although no rain gauges or other weather measurements are located in the monument, annual precipitation along the coast probably averages 100 inches or more. Precipitation on the Aleutian peaks and in the caldera is doubtless higher yet. Sunny days in the summertime are rare, and cloudy skies predominate in other seasons as well. High winds and rough waters often make navigation in small boats hazardous; low cloud ceilings make aviation takeoffs and landings difficult and sometimes impossible.

Biological Resources - Moist tundra dominates the river valleys along the coastline. These tundra meadows are composed of sedges with scattered willows and birch. There is a balsam-poplar stand in the Cinder River drainage. Shrub thickets are also found in the River Valley zone and the Ocean-Coastal zone, and are presently invading the Upland zone. Thickets of alder and willow line most of the river and stream valleys of both the Pacific and Bristol Bay drainages. Alpine tundra vegetates most Upland mountain slopes and parts of the Volcanic zone. The predominant species include avens, low heath shrubs, prostrate willows, and dwarf herbs. Non-vascular plants are also an important part of these vegetation communities.

Brown bears, moose, caribou, red fox, wolverine, beaver, river otter, shorttail weasel, mink, lynx, porcupine, tundra hare, arctic ground squirrel, terrestrial birds, waterfowl, clams, freshwater fish, five varieties of anadromous fish, stellar sea lions, harbor seals, and sea otters inhabit the Aniakchak area (Alaska Planning Group 1974).

Razor clams are found in Aniakchak Lagoon as well as on beaches to the south. In 1932 a cannery was built at the southwestern end of the bay and 12,948 pounds of clams were processed there that year. Clams were hauled from the harvesting areas to the cannery by automobile. The cannery operated for only a short time. Local sources have suggested that it failed because the clams were too sandy, because transportation costs were too high, or because intensive harvesting reduced the clam population to noncommercial levels. The clam population eventually rebounded, and in recent years Kodiak fishermen have harvested the Aniakchak Lagoon clam beds (Alaska Planning Group 1974).

NPS Natural Resources Inventories and Monitoring - No comprehensive biological inventories or monitoring of coastal resources have been conducted by NPS. In 1989, opportunistic counts of birds and marine mammals were made during aerial overflights following the EVOS. Black and white and color vertical aerial photography (1:24,000) was obtained in 1994 for the entire coastline, and selected portions were photographed in 2002.

Human Activities With the Potential to Affect Coastal Resources- Similar to Katmai, the marine coastline of Aniakchak is at constant risk from environmental threats associated with petroleum development, storage, and/or transportation. Aniakchak beaches were oiled by the 1989 EVOS and residual pockets of unweathered oil persist (Irvine In press).

Commercial fisheries harvest offshore resources and local subsistence uses harvest nearshore and coastal riparian resources. By-catch (mortality of non-target species) and physical habitat damage from bottom trawling have the potential to deplete local species and disrupt trophic structure and function. Humans frequently access subsistence resources by transporting wheeled all-terrain vehicles (ATV's) to the Aniakchak coast by boat and offload them on the beaches (McBirney pers comm). ATV's are then used to travel along the coastline or up river valleys to reach the interior of the preserve.

The coastline is the destination for recreational users that float the Aniakchak River (Brock pers comm.). Recreation-related activities include aircraft landings, camping, sport fishing, and beachcombing.

Literature Cited and Selected Bibliography -

Alaska Planning Group. (1974), Final Environmental Statement, Proposed Aniakchak Caldera National Monument, Alaska (Washington D.C., Department of the Interior).

Irvine, G.V. et al. In press. Multi-year persistence of oil mousse on high energy beaches distant from the Exxon Valdez spill origin, Marine Pollution Bulletin.

McGimsey, R. G.; Waythomas, C. F., and Neal, C. A. High stand and catastrophic draining of intracaldera Surprise Lake, Aniakchak Crater, Alaska. Geological Society of America Annual Meeting. [1994].

Prayer, C. David. Biological resource survey and oil spill impact assessment: Aniakchak National Monument and Preserve. 1989.

Ryan, Christopher. Oil spill clean up project in the Aniakchak area. 1989.

List of Maps
for
Southwest Alaska Network